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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 33.

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See Advertisement, page 27. 1872

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Cylinders 14 in. and 28 in. by 36 in. stroke.
Corliss valves to inlet and exhaust of both cylinders.
Belt Flywheel 16 ft. by 26 in.
Vertical Air Pump and Condenser, below floor level.
Worked by L. Crank from L.P. Crosshead.
120 I.H.P. CORLISS VALVE TANDEM COMPOUND ENGINE, by Sharples.
Cylinders 11 in. and 20 in. by 30 in. stroke.
Corliss valves to inlet and exhaust of both cylinders.
Rope Flywheel, 12 ft. dia.
Second motion pulley, 6 ft. diameter.
THOMAS MITCHELL & SONS, LTD.
BOLTON. 2405

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YARROW BOILERS. 2277

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Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Head, Wrightson & Co., LIMITED.
See Advertisement page 30, Nov. 14. 2402

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See Full Page Advt., page 59, Nov. 7.

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
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See Advert., page 57, Nov. 7. 8195

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T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 2006

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62 & 63, LIONEL STREET, BIRMINGHAM, and Principal Provincial Cities and Abroad.

New 530 B.HP. M.A.N. STATIONARY DIESEL ENGINE with accessories, as delivered from the makers under Peace Treaty, £2500; also Dynamo for same, seen London; also other sizes.—HICK-DIESEL OIL ENGINES LTD., 70, Queen Street, E.C. 4. 2043

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AND PROPULSION PROBLEMS.
Special designs only.
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Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2431

TENDERS.

SALE BY TENDER.

Tenders are Invited for

the PURCHASE, DISMANTLING and REMOVAL of PLANT (Engines and Generators, Switchboard and Air Compressors) from the Leeds Head Post Office.
Tenders will be received until Ten a.m. on Thursday, the 27th November, 1924.
Forms of Tender containing all particulars can be obtained on application to the Controller, Post Office Stores Department, Studd Street Depot, Islington, London, N. 1.
The Postmaster-General does not bind himself to accept the highest or any Tender.
By Order of the
POSTMASTER-GENERAL.
GENERAL POST OFFICE,
November, 1924. G 427

G. R.

GOVERNMENT SURPLUS.

TRANSFORMERS

LYING AT H.M. FACTORY, GRETNA.

For Sale by Public Tender.

Owing to the urgency of clearing the area, we are offering for sale by Tender, a large number of Transformers of all sizes up to 1000 K.V.A., 6600/440 VOLTS, 3 PHASE, 50 PERIODS.
CLOSING DATE OF TENDER HAS BEEN POSTPONED UNTIL DECEMBER 1st.
Particulars and Forms of Tender from
GEORGE COHEN & ARMSTRONG DISPOSAL CORPORATION, Abbey House, 2, Victoria Street, Westminster, S.W.1. G 396
Tel. No. Victoria 8040/4. Telegrams: "Cohstrong, Sowest."

STATE ELECTRICITY COMMISSION OF VICTORIA,
Melbourne,
Victoria,
AUSTRALIA.

Tenders are Hereby

invited for the SUPPLY, DELIVERY, etc., of the following for the Yallourn Power Scheme.
Copies of Tender Form and Specification will be available on application to:—
AGENT GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.
SPECIFICATION No. 25/1—6,600 V. TRANSFORMERS AND SPARES.
CHARGE:—£1 1s. for the first three copies of Tender Form, Conditions of Contract, and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A fourth copy and any further copies will be supplied for the sum of 5s. each. This charge is not returnable.
PRELIMINARY DEPOSIT:—A Preliminary Deposit of £50 is to be lodged with Tender.
The Specifications may be inspected at the above mentioned office.
The Commission does not bind itself to accept the lowest or any Tender.
Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m., 19th January, 1925.
R. LIDDELOW,
Secretary G 321

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of:—

1. FOUNDRY COKE.
2. PAINTS, DRYSALTERIES, etc.
3. SCREW JACKS.
4. WROUGHT IRON.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.
Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tender for Foundry Coke," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 28th November, 1924.
The Directors do not bind themselves to accept the lowest or any Tender.
A charge, which will not be returned, will be made of 5s. for each copy of Specification No. 1, of 10s. for each copy of Specification No. 2, and of 2s. 6d. for each copy of Specifications Nos. 3 & 4.
Copies of the Drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. ROBERT WHITE & PARTNERS, of 3, Victoria Street, Westminster, S.W.1.
A. MUIRHEAD,
Managing Director.
91, Petty France, S.W.1.
12th November, 1924. G 412

BENGAL-NAGPUR RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for:—

GUNMETAL, LAVATORY AND OTHER FITTINGS FOR CARRIAGES.
Specification and Form of Tender can be obtained at the Company's Offices, 133, Gresham House, Old Broad Street, E.C. 2, on or after 17th November, 1924.
A fee of 20s. will be charged for the Specification, which is NOT returnable.
Tenders must be submitted not later than NOON on Tuesday, 2nd December, 1924.
The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the order.
By Order of the Board,
R. C. VOLKERS,
Secretary. G 422

CITY OF LIVERPOOL.

LANCASHIRE BOILERS.

The Corporation invite

Tenders for the Construction

of THREE LANCASHIRE BOILERS at the Public Baths.
Specifications and other particulars may be obtained on application to the Engineer and Chief Superintendent, Baths Department, 75, Dale Street, on payment of One Guinea, which will be returned on receipt of a *bona fide* Tender.
Tenders must be enclosed and sealed up in the official envelope provided, and delivered by letter post at the Town Clerk's Office, not later than Noon on Wednesday, the 10th December, 1924.
The Corporation do not bind themselves to accept the lowest or any Tender.
WALTER MOON,
Town Clerk.
Liverpool, 18th November, 1924. G 451

CITY OF LIVERPOOL.

BOILER SEATINGS.

The Corporation invite

Tenders for the Construction

of SEATINGS for Three Lancashire Boilers at the Public Baths.
Specifications and other particulars may be obtained on application to the Engineer and Chief Superintendent, Baths Department, 75, Dale Street, on payment of Half a Guinea, which will be returned on receipt of a *bo a fide* Tender.
Tenders must be enclosed and sealed up in the official envelope provided, and delivered by letter post at the Town Clerk's Office, not later than Noon on Wednesday, the 10th December, 1924.
The Corporation do not bind themselves to accept the lowest or any Tender.
WALTER MOON,
Town Clerk.
Liverpool, 18th November, 1924. G 470

GREAT NORTHERN RAILWAY (IRELAND).

The Directors are prepared to receive

Tenders for the Supply of:—

BULL-HEAD RAILS.
FLAT-BOTTOM RAILS.
and FISHPLATES
(of British Standard Sections);
also
CAST IRON CHAIRS.
Specifications, Drawings, and Forms of Tender can be obtained from the undersigned.
Tenders made out on forms supplied by the Company should be delivered, under sealed cover, endorsed "Tender for Rails, &c.," not later than Ten a.m. on Friday, 12th December, 1924.
The Directors do not bind themselves to accept the lowest or any Tender.
J. B. STEPHENS,
Secretary.
Amiens Street Station,
Dublin.
17th November, 1924. G 440

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 5th December,

Tenders for the Supply of:—

CRUDE OIL ENGINE GENERATOR SETS.
Tenders must be made on forms, copies of which, with Specification, can be obtained at these Offices on payment of 10s. each (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.
S. G. S. YOUNG,
Secretary.
Offices: 91, Petty France,
Westminster, S.W. 1.
19th November, 1924. G 465

COPPERSMITHS.

COPPERSMITH'S BUSINESS FOR SALE BY PRIVATE BARGAIN.

The Subscribers are prepared to receive

Offers for the Goodwill,

BUILDINGS, MACHINERY, PLANT, PATTERNS, TOOLS, STOCK-IN-TRADE and OFFICE FURNITURE belonging to JOHN MILLER & CO. (Coppersmiths) Limited (in Liquidation), 86, Dale Street, Glasgow.
The Buildings are valued at £2,500, over Ground Burdens of £168 2s. 3d. per annum. The Machinery, Plant and Office Fittings amount, per Inventory and Valuation, to £2,309 17s. 6d., and the Tools and Stock-in-Trade to £2,709 10s. 3d., or thereby.
The premises are well situated and consist of a corner steading of ground, the extent of the area being 1560 square yards or thereby with frontages to Dale Street, and Wallace Street, adapted for carrying on a large Trade.
Intending purchasers may view the Machinery, Plant, Stock-in-Trade, etc., on presentation of cards of admission, which can be obtained from the Subscribers.
The Subscribers do not bind themselves to accept the highest or any offer.
THOMSON McLINTOCK & CO.,
Chartered Accountants,
216, West George Street, GLASGOW.
13th November, 1924. G 415

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES:—
1. BODY IRONWORK and FITTINGS for Railway Carriages.
2. WHEELS and AXLES for Railway Wagons.
3. RAILWAY WAGONS.

Tenders due on the 12th December, 1924.
Tender Forms obtainable from above. G 461

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, COPTHALL AVENUE, LONDON, E.C.2, invite

Tenders for:—

1. CLOTHS, &c. ... ... Fee 10s.

Tenders are due by Eleven a.m. on 2nd December, 1924. Tender forms obtainable at above address. Fees not returnable. G 469

CONTRACT No. 236.

THE DIRECTORS OF THE MANCHESTER SHIP CANAL COMPANY are prepared to receive

Tenders from Experienced

Contractors for the CONSTRUCTION and COMPLETION of TWO FIVE STOREY TRANSIT SHEDS, NOS. 7 & 9; THE EXTENSION OF THE GRAIN SUBWAY, WITH ALL ANCILLARY WORKS at No. 9 Dock, Manchester Docks.
Each Shed is to be 470 ft. in length, 110 ft. in breath, and five storeys in height. The Sheds and the Subway Extension are to be of REINFORCED CONCRETE on existing foundations.
The Drawings may be inspected, and copies of the Specification, Bill of Quantities and Form of Tender can be obtained at the Office of the Chief Engineer (Mr. H. A. REID, M.Inst.C.E.), 41, Spring Gardens, Manchester, on and after the 24th day of November, 1924, on payment of a deposit of Ten Guineas which will be returned on receipt of a *bona fide* Tender.
Sealed Tenders, addressed to the undersigned, and endorsed "Tender for Transit Sheds," should be delivered at this Office on or before 10.0 a.m. on Monday, 22nd day of December, 1924.
The Directors do not bind themselves to accept the lowest, or any Tender.
F. A. EYRE, Secretary.
41, Spring Gardens,
Manchester,
18th November, 1924. G 459

HAYFIELD RURAL DISTRICT COUNCIL.

MELLOR WATERWORKS.

The Hayfield Rural District Council invite

Tenders from Contractors for

PROVIDING AND LAYING about 7¾ miles of 6in., 5in., 4in. and 3in. CAST IRON PIPES, with all necessary Valves, Hydrants and Apparatus, and also for CONSTRUCTING TWO MASS CONCRETE TANKS at Hayfield and Mellor respectively.
The Drawings and Specifications may be seen at the Office of the Surveyor to the Council at Hayfield, Derbyshire, by previous appointment, or at the Offices of the Engineers, Messrs. G. & F. W. HODSON, M.Inst.C.E., M.Cons.E., Bank Chambers, Loughborough, from whom copies of the Schedules of Quantities may be obtained on deposit of Cheque for £5 5s., which will be refunded to Contractors making a *bona fide* Tender, on the return of the documents to the Engineers.
Sealed Tenders on the form supplied, endorsed "Tender for Mellor Waterworks," are to be sent to the undersigned not later than Monday, the 15th day of December, 1924.
The Council do not bind themselves to accept the lowest or any Tender.
J. R. BOWDEN,
Clerk to the Council.
Council Offices,
High Street, New Mills,
via Stockport.
17th November, 1924. G 447

APPOINTMENTS OPEN

PLYMOUTH EDUCATION AUTHORITY.
PLYMOUTH AND DEVONPORT TECHNICAL SCHOOLS.

Principal—W. S. TEMPLETON, M.A., B.Sc., A.M.I.E.E.

Required for the Day and

Evening Classes, LECTURER in Civil and Mechanical Engineering. Applicants must have Engineering Works experience and also some academic qualifications. The commencing salary will depend upon previous experience. Maximum of present scale £500 Graduate, £400 Non-Graduate, per annum. Last day for receiving applications, 3rd December, 1924. Further particulars from E. CHANDLER COOK, Secretary for Education, Cobourg Street, Plymouth. G 473

OVERSEAS.

CAPE TECHNICAL COLLEGE, CAPE TOWN.

Applications are Invited for

a LECTURER in the Engineering Department.
Graduate with workshop and drawing office experience, evidence of teaching ability, to teach Engineering Drawing, Heat Engines, Mechanics and Electrotechnics. Other special technical qualifications and experience may be taken in lieu of a degree or diploma. Salary £400–25–500.
The successful candidate must submit a certificate of health, conditions of service may be had on application to the undermentioned.
Applications, in duplicate, must be mentioned with certified copies of testimonials giving evidence of workshop experience, teaching ability, technical qualifications and stating age of applicant, before the 8th December, 1924.
Applications to be sent to:—
CHALMERS, GUTHRIE & CO., LTD.,
9, Idol Lane,
London, E.C.3. G 457

WOOLWICH POLYTECHNIC, S.E.18.

Wanted, Engineering

WORKSHOP INSTRUCTOR for the Fitting and Machine Shop, and to Lecture on Workshop Processes. Age over thirty. Wide practical and recent workshop experience and good technical knowledge essential. Salary according to I.C.O. scale.—For further particulars, apply, PRINCIPAL. G 474

Analyst Junior Assistant

REQUIRED in Engineering Laboratory. Must be used to routine analysis.—Address, stating age, and experience, G 431, Offices of ENGINEERING.

Manager Wanted with Ex-

perience in general engineering and mechanical handling plant, also modern foundry practice; must be capable designer. Applications treated in confidence.—Address, stating experience (in detail), age and salary expected, G 432, Offices of ENGINEERING.

Works Manager to Take

charge of engineering works and foundry, about 500 hands, steam turbines, steam engines, and refrigerating machinery. Dane preferred.—Address, giving full particulars of past experience, to ATLAS COMPANY, LTD., Copenhagen, L. G 434

Wanted, Sales Manager,

Building and Kindred Industries.—A London house of manufacturers requires the services of a gentleman who is an expert Sales Manager and organiser. The product is a technical one selling to Architects, Structural Engineers, Builders, Builders' Merchants, Contractors, etc., and acquaintanceship in these spheres together with experience or knowledge of concrete construction and/or structural engineering would be an advantage. State age, full qualifications, sales managership experience, if capital available, etc., in strict confidence.—Address, G 381, Offices of ENGINEERING.

JODHPUR RAILWAY.

JUNIOR LOCOMOTIVE OFFICER.

Messrs. RENDEL, PALMER & TRITTON, Consulting Engineers to the above Railway, are prepared to receive

Applications (by Letter only)

from duly qualified candidates for APPOINTMENT to the above vacancy.
Applicants must be Public School men, about 25 years of age and unmarried, and must have a good technical education at some recognised Engineering College, and have passed the Associate Membership Examination of the Institution of Civil Engineers, or the Associate Membership Examination of the Institution of Mechanical Engineers, and have served either a pupilage or apprenticeship in Locomotive Shops in the United Kingdom, together with some drawing office experience. Preference will be given to one who has also had experience in the running department and/or of traffic working.
SALARY:—Rs. 525 per calender month to commence, rising according to scale laid down by Government of India Rules (approximately Rs. 50 per month annually). Salary commences on day of embarkation for India.
TERMS:—A three years' agreement in the first instance, first-class free passage to India, and by rail to Jodhpur. The selected candidate will be required to pass a strict medical examination before final appointment.
Letters of application, giving the candidate's age, details of general and technical education, training and subsequent career (in chronological order) with dates, accompanied by COPIES ONLY of testimonials, Army Certificates, etc., should be addressed to Messrs. RENDEL, PALMER AND TRITTON, Appointments Department, 1914, Dartmouth Street, Westminster, S.W.1, not later than 25th November, 1924. G 409

Engineering Assistant

WANTED. Must have good Scientific and general engineering training and be competent to interview, exploit for orders and arrange for their execution. Man with good personal knowledge of Industrial Engineering firms preferred. Age not over 35.—Address, SCIENTIFIC, WILLIAM PORTEOUS & Co., Advertising Agents, Glasgow. G 367

PORTSMOUTH WATER COMPANY.

ENGINEERING ASSISTANT.

Permanent Engineering

ASSISTANT, about 25 to 30 years of age REQUIRED by the Borough of Portsmouth Waterworks Company, as early as possible in the new year. Applicants must have a good knowledge of Waterworks design and construction, both practical and theoretical, and must also be good Surveyors and Draughtsmen. Previous personal experience in Waterworks maintenance, including pumping machinery, would be an advantage, and an Associate Member of the Institution of Civil Engineers would be preferred. Salary £350 per annum, rising annually, by £25 to £450.—Applications on Forms which will be provided on application to the ENGINEER and GENERAL MANAGER, Waterworks Company, Portsmouth, must be delivered not later than Friday, December 12th, next. G 353

CITY OF BIRMINGHAM EDUCATION COMMITTEE.

MUNICIPAL TECHNICAL SCHOOL.

HEAD OF ENGINEERING DEPARTMENT.

The Education Committee invite

Applications for Appoint-

ment to the POST of HEAD of the ENGINEERING DEPARTMENT of the Municipal Technical School. The post is a full-time one and the salary scale is £650 per annum, rising, subject to satisfactory service, by annual increments of £50 to £800 per annum.
The above-mentioned salary will be subject to a deduction of 5 per cent. in respect of the voluntary abatement of salaries, and also to the usual deduction of 5 per cent. in respect of contributions to the School Teachers' (Superannuation) Acts.
Particulars of the duties and conditions of the appointment, together with form of application, may be obtained from the Principal, Municipal Technical School, Suffolk Street, Birmingham, or from the undersigned.
Canvassing will be a disqualification.
P. D. INNES,
Chief Education Officer.
Education Office,
Margaret Street,
Birmingham.
7th November, 1924. G 399

REPARATIONS AND THE BRITISH ENGINEERING INDUSTRY.

(From a Correspondent.)

I.—General Implications of the Dawes Plan.

The putting into operation of the Dawes Report has aroused much controversy as to the desirability, from the point of view of this country, of the payment of German reparations. The spread of economic knowledge since the days of "Make the Germans pay" has brought realisation of the fact that international payments on a large scale are a two-edged weapon and may harm the recipient no less than the payer. On the other hand, four years of depression, due to European chaos, have led to a fervent desire for stability. Since the settlement of reparations is seen in the light of the Ruhr episode to be an indispensable preliminary to a general settlement, there is a tendency in some quarters to acclaim it without counting the cost.

As the Dawes plan is already in operation, discussions of its desirability are belated. It is intended here to assess as far as at present possible the effect of the plan upon the British engineering industry. To achieve this object a brief survey of the general implications of the Dawes scheme will be necessary in order to draw attention to the principal aspects which affect engineering. The object of the Dawes plan is firstly to make possible and, secondly, to ensure the payment of reparations by Germany. In order to make it possible for Germany to start payment, the first essentials are that her Budget should be balanced and her currency stabilised. In order that she should continue payments, it is essential that such stability be maintained for the future. In the opinion of the experts, stabilisation of currency and balancing of the Budget are interdependent. They can be attained readily with the help of a foreign loan of 40,000,000*l.* and various financial measures, but can only be maintained permanently if, in the words of the Report, "Germany's earnings from abroad are equal to the payments she must make abroad, including not only payments for the goods she imports, but also the sums paid in reparation."

The plan, therefore, draws a distinction between the "German taxpayers' capacity to pay" and "Germany's capacity to make payments abroad." The "German taxpayers' capacity to pay" is capable of estimation, being the experts' estimate of the difference between Germany's maximum revenue and minimum expenditure. Their estimate for the first year is 50,000,000*l.* in a "transition period" of three years 61,000,000*l.*—82,500,000*l.*, rising in the first "normal year" to 125,000,000*l.*, subject to such variations within certain limits in either direction as her economic condition may warrant. It is provided accordingly that payments shall be made by Germany (*a*) from her ordinary Budget (*b*) from railway bonds and transport tax (*c*) from industrial debentures into the Allies' account in the hands of the Agent for Reparation Payments, but that the Agent will transfer abroad from time to time only so much of such sums as can be transferred without danger to German currency stability —*i.e.*, an amount not greater than the excess of German earnings abroad over her payments abroad on account of imports, in conformity with the paragraph quoted above.

In short, Germany is to be set on her feet again, but she is to pay handsomely for the privilege. Formidable and, indeed, hopeless as would be the prospect to most countries of paying 125,000,000*l.* a year, the experts believe that it rests within Germany's capacity to do so. After paying a tribute to the qualities and character of the German workpeople and the administrative organising and scientific genius of her industrialists, they state: "Ever since 1919 the country has been improving its plant and equipment. The experts appointed to examine the railways have shown in their report that expense has not been spared in improving the German railway system. Telephone and telegraph communications have been assured with the help of the most modern appliances. Harbours and canals have been developed. Lastly, the industrialists have been enabled to increase an entirely modern plant which is now adapted in many industries to produce a greater output than before the war. Germany is, therefore, well equipped with resources. She possesses the means for exploiting them on a large scale. When the present credit shortage has been overcome, she will be able to resume a favoured position in the activity of the world."

The future will show whether this belief of the experts is justified or not. If it is not, whatever be the reason, the Agent for Reparation Payments will not transfer abroad the funds accumulating in his hands—that is to say, reparations will not be paid and the problem under discussion will not arise. But if the experts are right and Germany succeeds in building up a favourable trade balance of 125,000,000*l.* per annum and so discharging her debt, what does this mean in terms of export trade?

The building up of an export surplus will depend on a decrease of imports or an increase of exports or a combination of both of these. In 1913 and 1922 the German trade balance was as follows (stated for convenience of comparison in 1922 values):—

	Billions of Gold Marks.	
	1913.	1922.
Imports	18	6¼
Exports	19¼	6¼

Of the 1913 exports 16½ billions were "visible" and 3 billions were "invisible." The total income from invisible sources not only covered the adverse trade and special balances, but left an average surplus of 400 millions a year for foreign investment. The annual average value of goods and specie not paid for with exports were:—

	Billions of Gold Marks.
1894–1898	1,074
1899–1903	1,218
1904–1908	1,720
1909–1913	1,675

Of the invisible sources of income which paid for these amounts, Germany's 20 billions of foreign investments are almost entirely wiped out. The bank balances held abroad yield only a small return. Shipping income is about one-third of the pre-war totals, while banking and insurance earnings and commissions have been proportionately reduced. The means with which Germany met her trade deficits before the war are, therefore, almost entirely eliminated, and her export trade provides her only means of paying for food and raw materials and meeting reparation payments abroad.

In the first place, therefore, the question arises whether Germany can reduce her imports and to what extent. For the years 1911–13, foodstuffs and factory materials comprised 86 per cent. of the total of all German imports, the largest items of raw materials being:—

	Per cent. of Total Imports.
Cotton, wool and silk	19·8
Raw copper	5·3
Hides and skins	10·0
Iron ores and pig-iron	5·0
Rubber	2·3
Tin, lead and aluminium	1·8
Chemicals and dyestuffs	6·4
Wood	6·4
Foodstuffs	26·3

Germany's loss of population and territory under the Peace Treaty may be expected to reduce the volume of her imports as compared with 1913, but will probably not affect these percentages much when normal economic conditions are restored. Even during the post-war dislocation there has been no fundamental change in the relative proportions of these imports.

It will be clear, therefore, that no great reduction of imports as compared with 1913 will be possible without disrupting Germany's economic organisation. On the contrary, it is anticipated that, quite apart from reparation payments, there is room for an expansion of imports from the 1923 basis (in that year her imports were estimated at 304,000,000*l.* and exports 303,000,000*l.*) in order to meet Germany's bare requirements. This will necessitate a considerable increase of exports, since with imports at their present level she has a slight adverse balance. Having restored her trade balance she will be compelled to increase her imports of materials in order to make reparation payments by a surplus of exports. After reaching equilibrium any increase of exports will not, therefore, be a net sum available for reparations. The amount available will be the increase of exports less the increase of imports. What the effect of this in terms of competition will be may be judged from its severity with the German trade balance at its present proportions. At least it will be clear that intensive production for export is her only resource.

On the other hand, it must not be overlooked that before the war Germany competed with Great Britain on these lines. She has done so since the war and, quite apart from reparations, she would no doubt do so again in any case once she got on her feet. The effect of the reparation payments is, therefore, merely to compel her to do immediately and on a specified scale what she would no doubt do in any case eventually. Moreover, this country will receive, in accordance with the Spa percentages, one-fifth of the total reparations, or about 25,000,000*l.* a year, and as long as Germany does not take orders away from us to a greater value than that, it may be claimed we shall not be losers. It is only in so far as the payments made by Germany accrue to others than ourselves that there are no balancing advantages to offset the disadvantages of competition.

The balance of advantage accruing to this country may therefore be expected to depend on how far this country will have to bear the brunt of the German competition in relation to our share of one-fifth of the reparation payments and how long we continue to receive such payments. It is impossible to say how these tendencies will work out, but if the result of pressing the debtor country to pay is to cause it to offer competitive goods at a lower price than it would otherwise, the particular industries in the creditor country which provide these goods are bound to suffer even though there are balancing advantages for the creditor country as a whole.

It will be objected no doubt that the restoration or normal conditions in Germany, following upon the adoption of the Report, will make her production costs approximate more closely to our own, and thereby diminish the advantage she has enjoyed for the past few years in competition. This argument seems to beg the question.

The basis of the Report is, as we have seen, that Germany's payments must not exceed her surplus of exports. Germany can only sell this huge surplus of exports if she produces on an enormous scale and offers her goods very cheaply. If her costs of production increase through higher taxation or through labour and material charges being greater, she will have to reduce them in another direction. If all rise she will have to choose between defaulting and transferring a disproportionate share of the increased burden to her sheltered industries in order to enable her export industries to flourish. The eventuality of default is beyond the scope of this article, but there is sufficient evidence in the recent decree of the German Government making substantial reductions in taxation to all the important export industries as to which of the alternatives she will adopt.

If, then, Germany's natural advantages in the matter of equipment, labour costs and virtual absence of capital liabilities were not sufficient, or if they were in any way to be lost or diminished by the operation of the Dawes Report, we may be certain that they would be artificially reinforced by the German Government at the instance of the Agent for Reparation Payments acting on behalf of the Government of this country and her Allies.

It is as yet early to look for the results which have been anticipated above, but the following extract, taken from a Berlin communication to the American journal, *The Iron Age*, is significant "*Berlin, Germany, September* 25: The predicted era of a sharp trade competition, a necessary outcome of the Dawes Reparations settlement, has begun. From all Germany's neighbours in Central and Northern Europe come reports of increasing German underselling, and from England comes the complaint that German construction materials are being increasingly imported at lower than English prices. The fact that the German increase in unemployment has come to an end, whereas the English unemployed again are increasing, and already number about 400 per cent. more than in Germany, has brought into the sphere of discussion the coming German export boom." It is concluded, therefore, that Germany's payments will result in

intensive production for export and that any advantage which may be expected to accrue to this country as a whole will be gained at the expense of those British industries which compete with Germany's export industries. In a subsequent article it is proposed to examine which industries these are and what position the engineering industry holds among them.

GEAR-TOOTH TESTING.—I.

By Joseph Horner.

With each refinement in the production of gears, exacter measurement and testing become more imperative. Teeth may not be cut of equal thickness, or pitch or profile. Diameters may become distorted in consequence of heavy cutting, or during hardening. Bores and peripheries may not be concentric. These errors not only conduce to more rapid wear, but they are a fruitful cause of noise, which is especially noticeable in the high-speed gears now enclosed in boxes. These facts are reflected in the increasing numbers and the great variety of gear-testing machines and gauges now in use. The variations mainly correspond with the particular element or feature which it is desired to check, and with the class of gear tested.

Tooth thicknesses are tested with fixed gauges, or with vernier calipers—the first being used for ordinary commercial gears, the second for more precise and fine measurements. Though pitches are referable to the circular basis, the tooth thicknesses must correspond with the chord pitch. The two correspond only in the rack; the difference is very marked in small pinions, but it lessens as wheels increase in diameter. Tooth thicknesses in cut gears which have little or no flank clearance, must be held very close to size, or they will mesh either too tightly or too freely, and the inexactitude will be aggravated by slight departures from concentricity, or by want of uniformity in the profiles.

Fixed gauges are very convenient to use, since once they are prepared no further calculations are necessary; but a good stock is necessary, since, strictly, a separate gauge should be used for every different number of teeth. If a limited number of standard gauges is prepared, these can only be, like sets of standard-disc gear cutters, approximately correct for the largest number of gears produced. The Gleason Works make a series of standard gauges, one for each diametral pitch from 2 diametral pitch down to 16 diametral pitch, the measurement being taken for a gear selected about midway between a rack and a small pinion. These make the small pinions with teeth slightly thicker, and the larger gears with teeth thinner, than the precise measurements would show. If exact dimensions are necessary, then a vernier gauge must be set for each different gear.

The depth of the pitch circle varies in gears of the same pitch, measuring more from the points of the teeth in small pinions than in larger wheels. In Fig. 1 the chord distance CE is less than half the circular pitch. The points C and E make contact with the sides of the teeth above the pitch circle, because FC = GD, and therefore CE is less than the actual chord thickness; and the thickness CE varies with numbers of teeth, due to differences in the curvature of the arcs. To calculate the chord thickness KI of half the circular pitch, and the length to addendum, plus HD, let—

T = chord thickness of tooth KI.
H = height of arc or versed sine HD.
D = pitch diameter.
R = pitch radius.
A = angle = 90 deg. divided by the number of teeth in the gear.

Then T = D × sine of angle A.
H = R × (1 − cos. of angle A).

Tables are available by which the dimensions are obtained more readily, being calculated on a basis of 1 diametral pitch, and on a basis of 1 in. circular pitch. The B. and S. gear-tooth vernier Fig. 2, can be used for all pitches from 1 diametral pitch to 20 diametral pitch. The sliding jaw moves upon a bar graduated to read by means of a vernier to thousandths of an inch, and a tongue moving at right angles with the jaws is graduated similarly. It therefore measures the thickness, and the distance from the top to the pitch line; and compensation can be made for any error in the size of the blank when setting the distance to the pitch line.

The general objections to these methods are that, since the gauges make contact only on the pitch line, they wear rather rapidly, that they do not check the pitch of adjacent teeth, and that the fixed gauges do not indicate amounts of inaccuracy in tooth thicknesses. To reveal these errors, more refined methods are necessary.

A shop system of long standing which tests the easy running of gears when set at their correct centres is also embodied in several gear-testing appliances. The gears are mounted on arbors, and are run round in mesh by hand, and the results noted, and sometimes recorded. This shows the mutual action of the teeth, whether they mesh too tightly or too freely, and reveals tight or easy contacts at different radial locations. But since these tests are limited to the matter of contact, they fail to reveal the degree of inaccuracy present in individual teeth. But for all common commercial gears the system is a satisfactory one, and it is therefore employed extensively, and appliances for its application are manufactured.

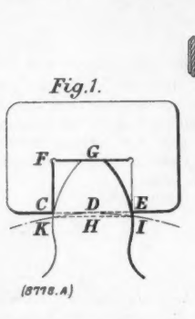


Fig. 1.

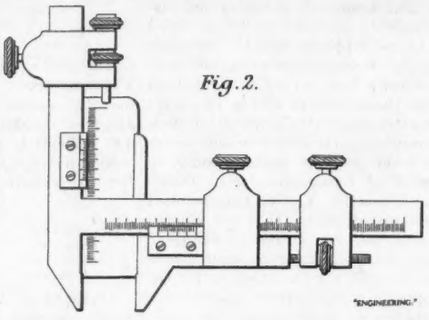


Fig. 2.

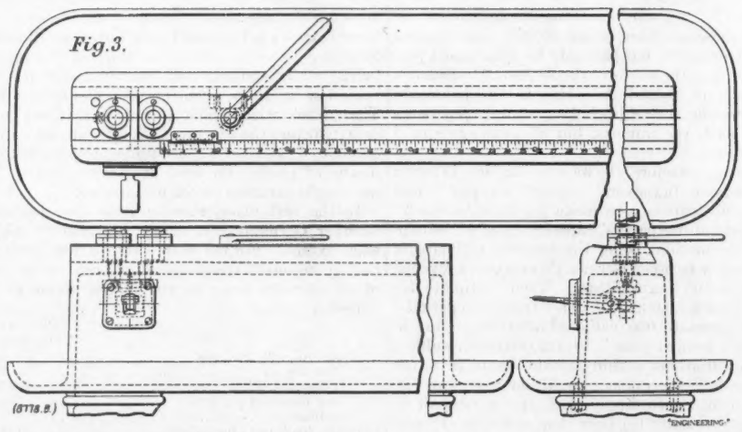


Fig. 3.

A spur gear testing machine, by Messrs. Brown and Sharpe, is shown by Fig. 3. A bed is mounted on legs. One gear is mounted on the fixed arbor to the left, the other on the movable arbor carried on a slide. The centre distance can be read to thousandths of an inch by means of the scale on the bed, and the Vernier plate on the slide. The heads have hardened steel bushings, with tapered holes to receive the studs that carry the gears. A lever at the front loosens the studs, one above clamps the slide. Metric scales and studs are supplied if required. When single gears have to be tested, a standard master gear is placed on the fixed stud, to mesh with the one to be checked.

A machine of the same type, by Messrs. J. Parkinson and Son, of Shipley, includes means for reading the results on a dial. Fig. 4 shows the standard machine with a pair of gears mounted on arbors. Fig. 5 illustrates the slides in outline, but set up for testing a master gear with a circular rack, a method to be described presently. One gear is fixed on a carriage at the left, that can be adjusted along the bed and clamped. The other is supported on a floating carriage to the right that rests on three balls, and has a plunger at one end, which is compressed with the adjusting screw A, that pushes the floating slide towards the left, where its movement is limited either with the adjustable stop screw B, or by the contact of gears being tested. A third screw C can be used to prevent movement of the floating slide, which, when held between the screws B and C, permits gears to be set within precise centres, and to enable these to be read, a scale is attached to the fixed slide and a vernier to the floating slide. Distances can be read to 0·001 in. and compared with the running centre distance. If very fine variations are required indicators reading to 0·0001 in. can be fitted. To avoid possibility of error in reading the vernier, the centres for repetitive work can be obtained by means of turned blanks of the correct pitch diameters, or of end measuring rods, or "go" and "not go" gauges between the arbors on the fixed, and the floating slides. Fig. 6 shows a gear blank being tested for diameter between the arbors, which are the gauging points. Here the dial indicates if the blank comes within the limits.

When testing gears with each other in mesh, and not with a standard or templet gear, they are set to the correct centre distance, and a selective method is adopted to determine the locations of thick or thin teeth or errors in pitch. The screw B in Fig. 5 is set to limit the movement of the slide, and the gears are run round. If the teeth have been cut correctly, the floating slide should have no movement, and the teeth no backlash, and the gears should rotate smoothly. If now the screw B is slackened and the plunger allowed to press the teeth closely into mesh, the rotation of the gears, unless they are perfect, will cause the floating slide to move irregularly. The extent is shown on the dial indicator. But the actual error for 14½ deg. pressure teeth is only one-half that shown by the indicator. If errors are discovered it is necessary to test the gears in more than one position, because it may happen that one or both will be eccentric with the bore. This will cause the pointer on the dial to advance and recede, unless the radius of one gear is complementary to that of the other, the larger one meshing with the smaller. To detect these errors, and those of individual teeth, every tooth in turn of one wheel should be tested with every tooth of the other wheel, and rotated only through the arc of contact, the process being reversed for each. A clamp is provided for use on the testing jig to limit the amount

of angular movement. But a better method is that of the employment of a master gear which has itself been tested with circular racks.

In Fig. 5, a master gear is shown mounted on the movable slide, and a circular rack having three teeth is in mesh with it. This rack reveals the presence of any variations in tooth contact, or errors in pitch. The single circular tooth seen in the upper part of the figure shows variations in the widths of tooth spaces, the single space templet to the right reveals any variations in the thickness of teeth. With these aids all the elements in a master gear can be corrected, to enable it to be used for testing the manufactured gears. The circular racks are not rotated, since they might conceivably be slightly eccentric, but they are adjusted endwise only. In the case of the rack with three teeth, the movement is limited to one pitch, the central tooth in its mid position being set centrally with the pitch point. In the two others, the total movement is only half a pitch, or a quarter pitch on each side of the pitch point.

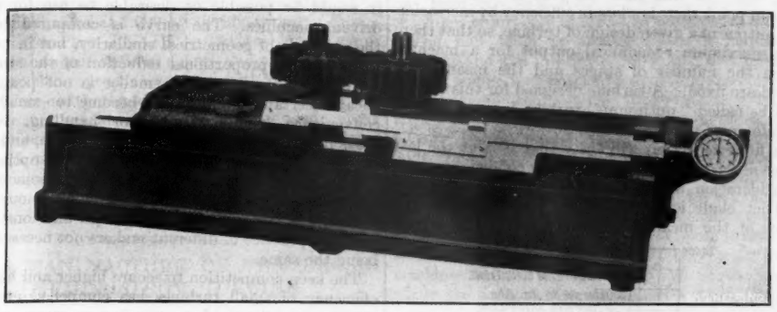
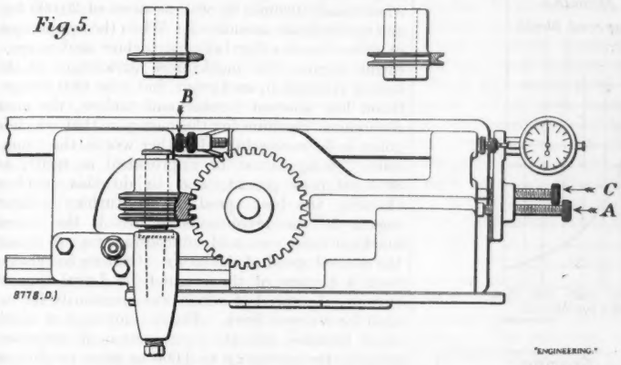


FIG. 4.

Fig.5.



If the readings of the indicator are tabulated for each tooth under test, the defects of gears can be detected at a glance by the inspector. To avoid the labour of plotting, an autographic recorder can be fitted. It comprises a drum carrying a chart which makes one revolution to each revolution of the wheel carried on the floating slide. A lever with long, and short arms, mounted on the slide carries at its longer end a pencil that traces a line on the chart. The short arm of the lever makes contact with an adjustable pin carried from the bed of the appliance, so that any movement of the floating slide produces movement of the lever, and as this coincides with the rotation of the chart, a line more or less regular is traced. The ratio of the length of the long and short arms of the lever is 50 to 1.

An appliance for gear tooth testing by Messrs. Gould and Eberhardt, of Newark, N.J., U.S.A., is illustrated by Figs. 7 to 9. It checks the concentricity of the blanks, of the pitch circle, and of the tooth spacing. The gears tested are those for the machine tools built by the firm, which have to be held within close limits to size.

The general aspect of the appliance is seen in Fig. 7, where two gears are shown in mesh, one of which may be a master gear. A lathe bed type of base is mounted on legs. A plate at the left carries a vertical stud interchangeable with others, to suit bores of different sizes, and a sliding plate at the right receives studs for meshing gears. Correct centre distances are set by means of the scale and vernier seen. When the gears are rolled, inaccuracies in radius, pitch and tooth thickness are detected. Before the teeth are cut, the blanks are tested for concentricity. The anvil of a dial is brought to bear against the periphery, and any eccentricity is detected.

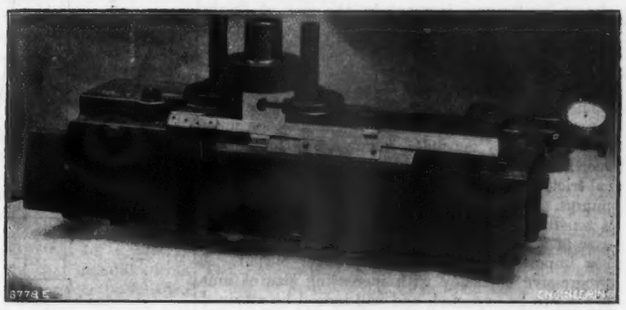


FIG. 6.

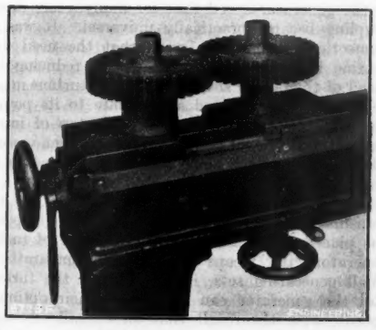


FIG. 7.

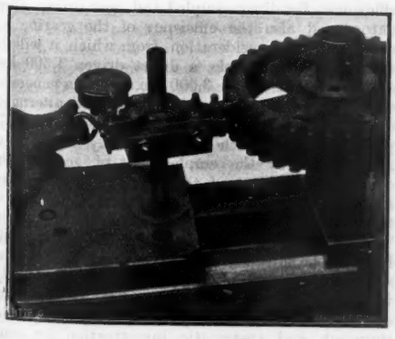


FIG. 8.

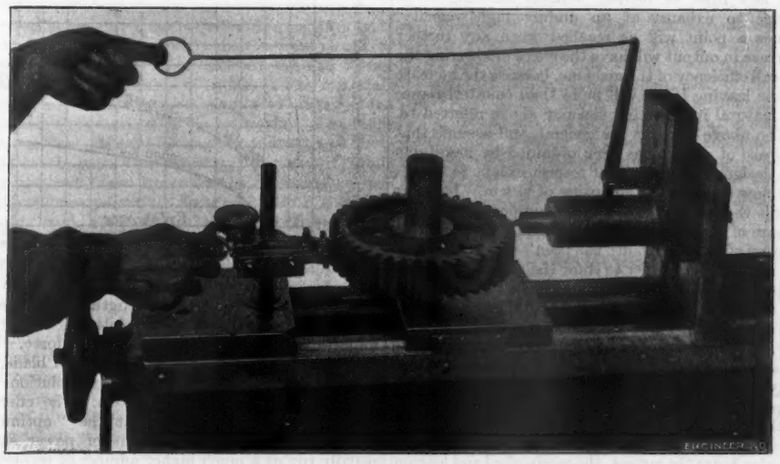


FIG. 9.

The appliance is modified to test the uniformity of the tooth spacing, Fig. 8, and the concentricity of the pitch circle, Fig. 9. In Fig. 8, a gear is mounted on its arbor, movable along the bed, on one slide, and on the other a testing apparatus with a dial is mounted, occupying the place of a gear. This carries two fingers—the farther one is adjusted to the pitch of the wheel to be tested, and the one seen nearest is adjustable, so that a tooth at the pitch line is gripped between the two fingers. The movable finger is the termination of the short arm of a lever, the long arm of which terminates in a contact with the anvil of the dial gauge. The reading is extremely close. The ratio of the lever to that of the movable finger is such that each division on the dial of the gauge indicates 0·0005 in. in the tooth thickness. After the dial reading for one

tooth has been taken, the gear is rolled round, and the next tooth tested, and so on. In this way the uniform spacing of a blank is checked, but its departure from circular accuracy is the subject of another test, Fig. 9.

Here the same appliance is used as before, but a bracket is mounted at the right to carry a plunger which is pulled into a tooth space with a rod and lever. The movable finger at the left is then entered into a space to make contact with one side of a tooth, Fig. 9, at about 180 deg. from the fixed plunger. The reading of the dial gauge is then taken, the gear indexed one tooth, and so on round. If the teeth have been cut eccentrically relatively to the axis of the gear, the readings of the dial will increase and diminish uniformly from a mean value. It is not necessary to set the finger exactly 180 deg. away from the plunger. The difference of one tooth makes no appreciable difference in the dial reading.

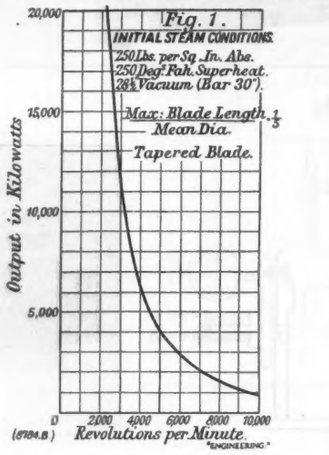
GEARED TURBINES OF THE ENGLISH ELECTRIC COMPANY.

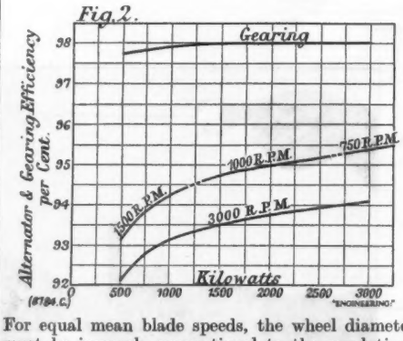
It is a matter of common knowledge that the almost continuous increase in the size of steam turbines since their first appearance as commercial machines has been accompanied by an equally noticeable reduction in their steam consumption per kilowatt-hour generated. This improvement in efficiency is not by any means attributable only to an increasing knowledge of the factors upon which efficiency depends. There are certain losses such as those resulting from steam-leakage, mechanical friction, and the power necessary to operate oil-pumps, governor-gear, &c., which while they absorb a sensible proportion of the steam-energy in the case of a small turbine, become relatively of much less importance in machines of larger output. A progressive efficiency with increasing size of unit is thus to be expected, and will indeed be attained until other factors become prominent. The larger the output the greater becomes the difficulty of securing an adequate passage for the steam through the last rows of blades, without allowing it to escape to exhaust at an unduly high velocity. Hence a point will be reached when any further increase in output will have the effect of lowering the overall efficiency of the machine, because the increase in the leaving losses will more than counterbalance the natural increase in efficiency above referred to.

The above remarks are general, and assume that increase of output has been obtained by modifying the design in no important respect except to permit the flow of a greater quantity of steam. In other words the factor "K" which is proportional to the square of the blade speed multiplied by the number of rows of running blades has been taken as constant for all cases. In order to show the magnitude of the improvement in efficiency due to increased output in a particular case we will consider a turbine developing 6,000 kw. with an overall efficiency of, say, 76 per cent. In such a turbine the losses due to steam leakage and to mechanical considerations may be taken as equal, together to, say, 5 per cent. Suppose now that a similar turbine is constructed, with the same number of stages and the same mean blade speed, but with blades lengthened so as to develop twice the output, the mechanical and leakage losses will be hardly affected. They will, therefore, only amount to 2·5 per cent. of the output of the 12,000 kw. machine, the efficiency of which will, therefore, have been raised to 78 per cent. independently of any increase in the hydraulic efficiency of the blading.

Increase of blade-length can, however, only be continued up to a certain point. Beyond this the centrifugal and bending stresses at the blade-roots become too great for safety, the discrepancy in pitch and velocity between the tips and the roots causes inefficient action of the steam, and there is a tendency for destructive vibrations to be set up in the blades themselves. When the practical limit of length is reached, the passage of any further quantity of steam increases the leaving losses at the last stage. With a given blade-length these losses increase as the square of the quantity of steam passed, thus bringing about a rapid reduction of efficiency with output. Supposing that the maximum practical length of blade to have been reached in the turbine considered above when developing 12,000 kw. with a leaving loss of 2 per cent., if the machine is called upon to develop 20,000 kw., the leaving losses will increase to 5·5 per cent., and the overall efficiency will be reduced from 78 per cent. to 76·38 per cent. It will thus be evident that after a certain point there is a loss in efficiency by increasing the output of a given design of turbine, so that there is a maximum economical output for a machine when the number of stages and the mean blade speed are fixed. A turbine designed for this output will be called "optimum" turbine for convenience of reference.

A little reflection will show that it is at the last stage of a turbine that the limiting conditions occur. Consideration of pitch at root and tip of blade restrict blade length to a maximum of thirty per cent. of the mean diameter of the bladed wheel.





For equal mean blade speeds, the wheel diameter must be inversely proportional to the revolutions per minute, so that blade length must also be inversely proportional to revolutions. A further important limiting factor is centrifugal force. This increases of course directly with length of blade, and as the square of the number of revolutions per minute for equal mean diameters. The effect of all these consideration is that the "optimum" turbine for a moderate output of power should usually run at a much higher number of revolutions per minute than is permissible for the driven machine. If the latter is an alternator producing current at the standard frequency of 50 cycles per second no speed higher than 3,000 revolutions per minute is possible on account of electrical considerations. Should a continuous current generator be driven by the turbine, commutation difficulties prevent a speed as high even as 3,000 revolutions being used except for machines of the very smallest sizes. Again, if the turbine is to transmit its power by ropes, the practical limits of rope speed combined with the necessity for a reasonable sized pulley, impose a speed of revolution upon a direct-coupled turbine which is altogether too low for economical design.

Fig. 1, above, gives a curve showing speeds corresponding to the maximum efficient output of a range of "optimum" turbines designed for modern conditions of steam-pressure, temperature and vacuum, namely, 250 lb. per square inch absolute and 650 deg. F. at the stop valve, and 28·5 in. of vacuum in the condenser. The leaving loss has in all cases been taken at 3 per cent. of the total adiabatic heat drop, and the greatest blade length as one-fifth of the mean diameter. It will be seen from this curve that the turbine speeds are much higher, especially in the case of small powers, than it would be possible or desirable to use for any driven machines. The curve is computed from the principle of geometrical similarity, but in practice a perfect proportional reduction of the size of all parts as machines get smaller is not possible, because certain details would become too small for convenience in manufacture or handling. Such parts have therefore to be increased in size, and the effect of this is in general to reduce the optimum speeds for machines of smaller output somewhat below the speeds shown in Fig. 1. The amount of such reductions is a matter of design and construction, the practice of different makers not necessarily being the same.

The keen competition to secure higher and higher efficiency of small turbines has compelled greater attention to be paid to the factors upon which efficiency depends and brought the ideal of the "optimum" design into the minds of designers when small turbines as well as units of 20,000 kw. and upwards are considered. When the competition in prime movers lay between turbine and reciprocating engine, the mechanical advantages of the former counted in its favour, but now that competition lies between turbine and turbine, the most economical machine for the money is that which is going to be successful. In other words, the "optimum" design must be approached as nearly as circumstances permit, and to do this involves choosing the best speed of the turbine without regard to the revolutions at which the driven machine must run, and interposing gear to obtain the desired speed of the latter. Gearing has always been a feature of the original De Laval type of turbine, the speed of which was necessarily far too high for a direct drive. The development of multi-stage turbines and the construction of generators suitable for speeds up to 3,000 or more revolutions per minute so far approximated the turbine speed to the generator speed that for many years direct coupling became practically universal. It was in connection with marine work that the need first became insistent for some means of reducing the speed of the driven shaft, so that the turbine might be designed for a speed appropriate to its power. Sir Charles Parsons took the bold step of introducing reduction gearing into turbine-driven vessels, where it has now become standard practice for all but the fastest ships.

The development of gearing suitable for the transmission of considerable power at high speeds has placed in the hands of the designer of turbo-generators the means of building comparatively small generating sets, in which both the turbine and the generator can be run at their optimum speeds, with the result that an overall efficiency can be obtained higher, in spite of the inevitable losses in the gearing, than could be secured by direct coupling. The curves in Fig. 2 show the efficiencies for direct-coupled and gear-driven alternators and also the efficiency of the gearing for outputs under consideration, from which it will be seen that, for example, a direct driven 1,500 kw. alternator running at 3,000 r.p.m. has a generator efficiency of 93·5 per cent., a slow speed alternator of the same output having an efficiency of 94·75 per cent., so that although there may be a loss of 2 per cent. by the employment of gearing, the combined efficiency of the gear-driven slow-speed alternator is barely ½ per cent. worse than that of the direct-driven alternator of the same output. The high-speed turbine used with the gearing will, however, be substantially more efficient than a slow-speed turbine for direct coupling, or, alternatively, will be much cheaper and smaller for the same efficiency. The whole question has been under thorough and systematic investigation for some time past by the engineers of the English Electric Company, with the result that a complete range of standard designs has been produced covering machines up to 2,500 kw. capacity.

The geared turbines of the English Electric Company follow very closely the designs of the larger machines manufactured by the firm. Such features

as oil-relay governing, blades milled from the solid bar forming their own distance-pieces, turbine-driven auxiliary oil pumps, Michel thrust bearings, and multi-tooth universal couplings are all embodied, and equal care is taken to ensure the accessibility of all parts which is characteristic of the larger machines. The general appearance of a geared set rated at 1,000 kw. is illustrated in Figs. 3 and 4, on Plate LXXIII. The turbine develops its rated output at 6,000 r.p.m., and thus obtains as high a blade speed as adopted with direct-coupled machines, with the advantage of a great reduction in size and weight. The actual mean blade speed of the turbine in question is practically 700 ft. per second, which is in fact greater than is often used with larger machines.

(To be continued.)

THE MANUFACTURE OF THE BRUSH-LJUNGSTRÖM TURBINE.

THE position which the double-rotation steam turbine, invented by the brothers Birger and Frederick Ljungström, now holds is due very largely to the enterprise of the Brush Electrical Engineering Company, Limited, of Loughborough, who acquired the manufacturing rights for the British Empire in 1912, and subsequently bought the patents outright. At the time the turbine was developed there were many makes of turbine on the market, nearly all being merely designers' modifications of the original machines of Parsons and Rateau. The Ljungström machine embodied the reaction principle, which is inherently the most efficient, but utilised it in a manner totally different from that of any existing turbine. The steam, instead of passing axially along a cylinder, flowed radially outwards from the centre to the circumference of two discs acting upon rings of blading projecting alternately from the discs. The two discs rotated in opposite directions, the blades therefore having twice the relative velocity of the blading in a single rotation turbine running at the same number of revolutions, so that a very high efficiency could be obtained with a comparatively small number of blade rings. The principle permitted the advantages of high efficiency, extreme compactness and freedom from troubles due to casing distortion to be obtained, and the only question was whether it could be embodied in a sound mechanical design. The constructional problems were new and difficult, but the engineering skill and courage of the inventors were equal to the occasion, and the very first Ljungström turbo-generator ever built is running to-day in a power station not far from London. This machine, which is rated at 1,000 kw., was fully illustrated and described in our issues of April 12 and April 19, 1912. Its efficiency ratio at full load was 73·6 per cent., based on steam conditions at the boiler side of the stop valve, this performance, we believe being better than anything previously obtained on a set of similar size. The reputation of the type for efficiency has been fully maintained, and there is probably no turbine of a size with which the Ljungström is able to compete, which will do its work with a lower steam consumption. In this connection it may be mentioned that in the latest report of the Electricity Commissioners on the generation of electricity in Great Britain, the power stations at Wallasey and Southport, both of which are equipped with Brush-Ljungström generating plant, come out at the top of their respective classes for overall thermal efficiency.

The Brush Company have now about two hundred Brush-Ljungström turbo-generators either in service or on order, some of these being in isolated plants in remote parts of the world, so that the reliability of the type is recognised as at least equal to that of any other kind of turbine. The increasing demand for their machines made it necessary for the company recently to put down a large extension to their works, this extension comprising a fine shop covering an acre of ground. Two interior views of this shop, which is about 580 ft. long, are given in Figs. 1 and 2 on Plate LXXIV. The shop is devoted to the manufacture of turbines of 3,000 kw. and over. The largest machines made at the present time are of 7,000 kw., two of this size being recently installed at St. Pancras power station, as mentioned in our account of the station published on November 7 last. Plans are, however, in progress for the manufacture of units of 10,000 kw. normal rated capacity, and the shop has been equipped with a view to dealing with machines of any size likely to be undertaken.

The new shop is architecturally a handsome building and the interior is lofty and well lighted. It is, of course, a steel-framed structure, the columns supporting the roof carrying crane-rails at different levels. The main cranes, the largest of which is of 50 tons capacity and 75 ft. span, are at a height of 36 ft. from the floor, and run the whole length of the shop. At one end of the shop a side gallery is arranged, 20 ft. wide and extending for a length of 240 ft. down the shop. This gallery contains some of the lighter machine tools, and between it and the farther wall runs a 20-ton crane to serve the large machines below. At the other end of the shop, where the turbines are erected, is a 6-ton Goliath crane running on rails laid across the floor of the shop, as shown in Fig. 2. The Goliath crane is exclusively for erecting purposes, and enables the erectors to proceed continuously with their work, without having to wait for the main crane overhead, which serves the whole shop. Not only, therefore, are the crane facilities ample for the expeditious lifting and removal of work, but the standard gauge railway lines running down the shop afford direct connection with the general railway system of the country, the works being immediately alongside Loughborough station on the L.M. and S. main line. Loughborough is also served by the L. and N.E. Railway, so that direct transportation is available between the works and all parts of Great Britain.

The new shop, being constructed for a specific purpose, is naturally laid out so that manufacturing can proceed from the rough castings to the finished product with the minimum expense of time and labour. The machines are arranged in order of their use and the work travels steadily through the factory, with the smallest possible amount of handling. The necessary movement of men and material is facilitated both by ample gangways and by the rule that all gangways shall be kept clear for traffic. To this end white lines are painted along the sides of every channel of traffic, and no material may be put down in such a way as to encroach on the space thus marked off for a passage. The shop has excellent natural illumination from the roof and from the large windows along one side, and equal care has been taken to render the artificial lighting as effective as possible. Exhaust steam is used for heating and a comfortable temperature can be maintained in cold weather. We were told that the pleasant and healthy conditions of the new shop had resulted in less lost time among the men employed there than among those working in the older shops.

Among the modern machine tools with which the new shop is equipped is the large vertical turning and boring machine, manufactured by Sir William Armstrong, Whitworth and Co., Limited, of Manchester, illustrated in Fig. 3 on page 700. The size of the machine will be gathered from the fact that the casting upon which the two tool-heads are operating is the end casing of a 5,000-kw. turbo-generator. It is said that work of this size can be turned or bored true to a thousandth of an inch on this machine, which is a very remarkable performance. The main driving motor is rated at 30 brake horse-power and a smaller motor of 5 brake horse-power is also provided, the latter to give the rapid power motion of the boring heads. Opposite the Armstrong-Whitworth boring mill is a large planing machine, made by Messrs. Joshua Buckton and Co., Limited, of Leeds. This has a stroke of 20 ft. and will accommodate work 10 ft. wide by 10 ft. high. It is used for condenser bodies and other large work. Possibly, however, the most striking machine in the shop is a large horizontal boring, milling and facing machine, built by Messrs. H. W. Kearns and Co., Limited, of Broadheath, Manchester. This machine, which is illustrated in Figs. 4 and 5, Plate LXXV, was the first of its kind to be constructed, and was designed particularly for machining large turbine casings and condensers. The table to which the work is bolted can be rotated, so that all sides of the work can be machined without resetting it on the table. The table measures 14 ft. by 8 ft. and the distance between the uprights is 18 ft. The vertical travel of the spindle slide is 7 ft. 6 in., and the facing slide will machine a surface up to 9 ft. diam. The platform on which the operator stands rises and falls with the slide, so that the machine adjustments are equally convenient for each at whatever height the spindle is working. Further, to facilitate operation the driving motors have push button control, one control being fixed to the head of the machine and the other being portable. The operator can thus operate it with ease and certainty from any convenient position, so that when necessary he can remain standing at the actual point where the work is being done. The main driving motor is of the variable-speed type, developing 25 brake horse-power and having a speed range between 700 r.p.m. and 1,200 r.p.m. The other motor, which is rated at 7½ brake horse-power at 750 r.p.m., operates the rapid-power motion. Fig. 4 shows the machine at work on a turbine casing, while Fig. 5 shows a condenser body being machined.

Opposite the Kearns machine is a large work-plate, 40 ft. long and 20 ft. wide, laid very accurately with its upper surface slightly above the floor level. The upper surface of the table is true within an error of 0·006 in. in 12 ft. The table is provided with bolt-slots, so that work can be fixed directly to it, and operated on by a horizontal milling, surfacing and boring machine, a horizontal drilling machine, and a portable radial drilling machine, all of which are mounted on the work-plate. The plate also carries a rotating table, which, when used in conjunction with the other machines, enables a great deal of machining to be done at one setting. The work-plate with various machines is illustrated in Fig. 6, on Plate LXXVI. The same regard for convenient and rapid work which characterises the machine lay-out is found in the facilities provided for erection. The Goliath crane has already been mentioned, but a reference to Fig. 2, Plate LXXIV, will show a further handy device to save the time and trouble of the erectors. The circular casting in the foreground is a stool having a machined flange on its upper side which corresponds with the exhaust flange of a standard size of turbine. Hence, by bolting the lower half of the turbine casing to the stool it is rigidly held at a suitable height, and erection of the whole machine can proceed without further support being required. The partially completed turbo-generator seen at the right-hand side of the illustration is standing on a similar fixed stool. After erection all machines are tested at the works, and in Fig. 7, Plate LXXVI, is shown a view of the test-room with three Brush-Ljungström turbo-generators in position for test. Facilities exist for the simultaneous testing of four units, each in conjunction with its own condensing plant.

On Friday last the directors of the Brush Electrical Engineering Company, Limited, invited a party of engineers and other guests to inspect the Loughborough works and to examine, not only the methods of manufacture of the details of the Brush-Ljungström turbine, but also the other departments of the works, where generators, transformers, motors, tramcars, and other articles of the company's manufacture are produced. The whole of the works, which cover 33 acres, were thrown open to the visitors, who were taken round in small parties under the direction of the chief members of the staff. The chief interest of the visit—at any rate, from the mechanical point of view—lay, perhaps, in the details of the turbine manufacture. The blades, although small and of the reaction type, are all machined from solid circular steel bar. When the inside and outside contours have been correctly formed, the blading, in long strips, is highly polished, the internal surface being done by girls who bring the strip into contact with an endless polishing band running over a roller of a size to suit the internal curvature of the blading. The strips are then cut up into blade lengths and the individual blades are welded into channel-shaped rings at each end, the whole forming an

extremely strong mechanical construction. The machining of the glands, which are, like most other details, of a type peculiar to the Ljungström design—was one of the most delicate machining operations, although the final result was a most effective and robust article. The whole of the manufacturing operations are fully standardised, and parts are made in batches and passed into store. Each part is inspected after each operation and a further inspection is made before it is passed into store. A general check upon quality of material is kept by means of a chemical and testing laboratory.

FRACTIONAL HORSE-POWER MOTORS.

A WELL-FINISHED and unusually adaptable group of fractional horse-power electric motors has been assembled for demonstration purposes at the premises of Messrs. Pooley and Austin, 34, Broadway, Westminster, London, S.W. 1. Constructed by the Wilson-Wolf Engineering Company, Limited, of Bingley, Yorkshire, these motors possess several interesting features. All parts have been standardised throughout the five sizes made, which range from $\frac{1}{15}$ to $\frac{1}{4}$ brake horse-power and run at speeds from 500 to over 6,000 r.p.m. The two smallest sizes, when series wound, are of the universal motor type, running on either direct or alternating current. The larger sizes are wound for direct current, or single, two-phase or three-phase alternating current, and these types are of uniform external dimensions. The framework of each is made up to permit of working in a horizontal or vertical position. The general design is such that the rotor and the stator may be punched from the one lamina of metal. The armature slots run at an angle to the length of the shaft to ensure silent running and the frame consists of steel stampings. The bearings of the universal type are self-aligning and self-oiling, the latter feature being ensured by a pad of soft material which carries a supply of oil.

Shunt-wound motors are provided for running on direct current, suitable rheostat controls being supplied, but up to $\frac{1}{8}$ h.p. the motors will start on a simple snap switch. This condition also holds for compound wound motors up to $\frac{3}{8}$ and series wound up to a $\frac{1}{4}$ h.p. One direct-current compound-wound motor is on view fitted up with a flexible shaft and drives a drill. To secure a high torque on the drill a 5 to 1 ratio reduction has been incorporated in this particular motor. Another useful application of the same motor, of $\frac{1}{8}$ h.p. and 3,200 r.p.m., is to the driving of a bench grindstone consisting of a 6 in. by $\frac{5}{8}$ in. wheel fitted with ball bearings and an adjustable work-rest, starting switch and main terminals. The set can be run from any lamp-holder. Different wheels may be fitted, the socket carrying each wheel being removable, and additional socket wheels being supplied. In all these cases the fields and bearings of the motors can be rotated and locked so that the bearings and oiling arrangements are uppermost. The rating of the motors provides for 25 per cent. overload for one hour and 50 per cent. overload for short periods without undue rise in temperature.

NOTES ON NEW BOOKS.

IT was Mr. Joseph Chamberlain who once observed that a great man resembled a mountain in that it was difficult for those close to either to make a fair estimate of the real magnitudes. The comparison seems to apply much more aptly to the late Lord Rayleigh than to the politician about which it was uttered. Whilst the relative standing of the latter has steadily diminished since his death, the lapse of years serves, if anything, to enhance the opinion entertained about the genius of the late Lord Rayleigh, and to-day many of those who are engaged in investigating difficult problems in electricity or hydro-mechanics find in his collected papers the clues needed for the solution of the problems in which they are interested. The biography of so original a thinker was well worth the writing, and the work has been sympathetically and interestingly carried out by his son and successor, whose "*Life of Lord Rayleigh*" has been published by Messrs. Edwin Arnold and Co. at 25*s.* net. The volume is quite suitable for general reading, the scientific labours of the subject being dealt with only so far as they can be made intelligible to the non-expert. A remarkable fact about the subject of this biography was that he was a seven-months' child. It is curious, in the light of after knowledge, to note that when Lord Rayleigh was placed as senior wrangler a paragraph appeared in the *Times* to the effect that his success was due "more to his perseverance than to his brilliant talent." Later on, when argon was discovered, another attack on Lord Rayleigh appeared in the same journal, and with equal lack of justification. One of Lord Rayleigh's most notable characteristics was his ready and generous appreciation of the work of other investigators, and in some cases he was responsible for bringing to light the neglected researches of certain pioneering thinkers. A notable case was that of J. J. Waterston, an engineer, who in 1845 sent to the Royal Society a paper establishing some of the most important propositions in the kinetic theory of gases. The referee, to whom the paper was submitted, said, "The paper is nothing but nonsense, unfit even for reading before the society." Lord Rayleigh's views on the teaching of mathematics are of very considerable interest, and he evidently had little sympathy with the demand that "rigid" proofs were necessary for those using mathematics for practical ends. His son relates that on one occasion he had objected to a "demonstration" in an elementary work as inconclusive, to which his father replied that he "daresay it is quite conclusive enough." If he were satisfied that a mathematical argument was substantially justified in the application he wished to make of it, he did not take much interest in a close criticism of it.

In celebration of the completion of its 20,000th locomotive, the firm of Henschel and Sohn, G.m.b.H., of Cassel, has issued, from its own publishing department, a pocket book on railway engines, under the title "*Des Lokomotiv Ingenieurs Taschenbuch*" (price 5 gold marks). The first railway engine of the company was built in 1848, but the firm of Carl Christian Henschel, originally bell founders at Giessen, goes back to the sixteenth century. The company now builds railway engines of all types, for main line and suburban traffic, fireless locomotives, electric locomotives and special types for colonial service. The company owns metallurgical works at Hattingen, on the Ruhr, and employs nearly 11,000 hands. The booklet, of 174 pages, is what it professes to be, a well-illustrated pocket book for the railway engineer.

Electric arc welding has much to recommend its use where economical fabrication of iron or steel structures is to be effected, or where repairs are necessary in existing plant. Only an intimate acquaintance with the methods and rates of working and with the physical actions involved and their effects, enables an estimate of what savings may be made by the process as compared with older practices. For long, engineers heard claims of the most astounding nature made by people who had plant or particular types of electrodes to sell. This condition could only exist when ignorance prevailed as to the limits within which the use of the arc welding process was possible. To-day we have reached the stage in development when most engineers have had some experience of the work, and we are settling down to a sane appreciation of what are the possibilities of joining metals by welding. In the early days much was claimed which was not possible of demonstration, and most of the literature on the subject showed unmistakable indications of the processes or plant which the author was most interested in advertising. We have received, at last, a book which does not show this taint, and though the author is associated with a firm making proprietary welding plant, his treatment of the subject can only be regarded as quite fair and impartial. This creditable book, with the title "*Arc Welding Handbook*," was written by Mr. C. J. Holslag, and is published by the McGraw-Hill Publishing Co., Limited, of 6 and 8, Bouverie-street, London, at a price of 10*s.* net. The references to machines and processes are general, the real purpose of the volume being to show methods of making the different types of joints and give practical hints on the performance of specific repair jobs. In this way it excels anything we have previously seen, and it will prove a welcome addition to the library of any workman who is hopeful of becoming an expert in a class of work in which success depends so much on the care and foresight of the operative.

The hand processes used in woodworking have been greatly reduced in number during recent years. This is not to be wondered at, when it is recognised that high rates of wages cannot be paid, unless the product of the labour can be marketed at prices which will more than meet the total costs. Under the conditions we

MANUFACTURE OF THE BRUSH-LJUNGSTRÖM TURBINE.

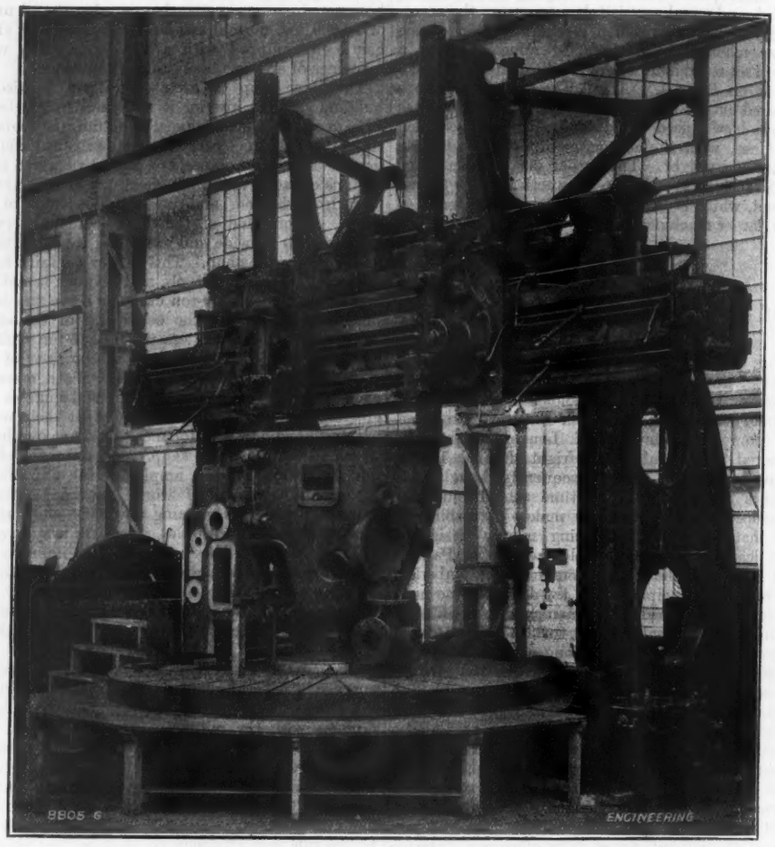


FIG. 3. VERTICAL BORING AND TURNING MACHINE; MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED.

have to contend with in the workshops to-day, production must be greatly increased, and the workmen must, therefore, become machine operators on specialised work, rather than skilled craftsmen, capable of using a great variety of hand tools. The rapid increase in the use of woodworking machinery in Great Britain has resulted from the necessity for reducing the high labour charges experienced in building construction, and recent exhibitions have given evidence of the extent to which the constructors have met the demands. In America the use of machinery for every repetitive type of work has grown enormously, and we have evidence of this in an encyclopedic work entitled "*Cosgrove's Handbook of Woodworking Machinery*," which was recently published by the Cosgrove Company of Owosso, Mich., U.S.A., and is distributed in this country by Messrs. William Rider and Son, Limited, from the Timber Trades Journal Office, 8–11, Paternoster Row, London. In this leather bound volume, which is arranged on the loose leaf system to permit periodical additions, practically every piece of woodworking equipment built in the United States is described, and the entries number more than one thousand. When similar machines are made by different makers the details of them are given in a way which permits of easy comparison. As every item is indexed, the description of any machine may be quickly located. The selling price of this exhaustive work is 3*l.* 12*s.* 6*d.*, which includes the cost of the upkeep service of additional leaves, bearing descriptions of new machines, for a year. Nothing so complete as this handbook has ever been attempted before, and even a casual inspection of it will convince anyone, who is interested in wood-working machinery, of its great value.

Mr. S. H. Higgins has compiled his volume on "*A History of Bleaching*," in recognition of the fact that an education in bleaching, as in other industrial arts, is incomplete without some knowledge of the evolution of that industry. He had already written a book on "Bleaching: A Resumé of Researches, 1908-1920," and his new volume is a historical supplement to that earlier publication. The present generation often has reason to admire what was achieved in ancient days by primitive means. Until the middle of the eighteenth century bleaching advanced little beyond what was known to Oriental nations and to Greeks and Romans in classical days. Lime, in the place of potash, and acids and chlorine were then introduced in order to shorten the months that good bleaching required; but it took a long time before the justified prejudice against the use of chemicals was overcome, and Germany insisted upon the examination of bleachers. In England the later developments have mainly been on the engineering side. The interesting volume (Longmans, Green and Co.; price 10*s.* 6*d.* net) might have been provided with an index.

The engineer has daily to deal with the most complicated systems of stresses, whereas the mathematical theory of elasticity provides satisfactory solutions for only the simplest problems. The question may well arise, therefore, as to how far the study of the academical side of the theory of stresses should be pursued by the practician, especially in view of the fact that in many cases theory indicates the existence of stresses of alarming magnitude in structures, which experience has proved to be perfectly safe. There is indeed reason to believe that increased knowledge of higher stress analysis has in recent years been responsible for a deterioration of design; and that where calculation and experience are in disagreement, the engineer is tempted to give undue weight to the former. Nevertheless, it would be a retrograde step for engineers to ignore the higher developments of theory, and we may hope in time to arrive at a theory of strength instead of, as now, merely at a theory of stresses and strains. Those who have the aptitude for mathematical study, will find an excellent presentation of the latter subject in "*Applied Elasticity*," by Dr. John Prescott, which has been published at 25*s.* net, by Messrs. Longmans, Green and Co. The distinctive characteristic of the treatise is the use made of Castigliano's principle of least work, although the author does not mention the name of this pioneer, and his treatment of the principle has little in common with that of Castigliano. The principle that the potential energy of strain must be a minimum seems to have been first set forth by Ménebréa in the Comptes Rendus for 1858, but the method has received less attention from theoretical writers on elasticity than its powers merit. This has probably been due in part to the circumstances that the theoretical writers have been in search of exact solutions, which are attainable only in the simplest cases. In these cases, alternative methods of analysis are perhaps simpler than the method of least work, but the latter method has the merit of providing approximate solutions to the more complicated problems. This use of the principle certainly would seem to be open to further development. Dr. Prescott employs it for the discussion of the equilibrium of thin curved rods, and to certain problems in the bending of thin plates. The discussion of the stresses in such plates is particularly complete, and embodies some original results, due to the author. Strain potential methods are also largely employed in determining the vibration of shafts or of rotating discs, with which problems the author deals very fully.

In an interesting paper which he read before the Royal Society two years ago, Sir Robert Hadfield stated that careful estimates appeared to show that there was at present an annual loss of over 40,000,000 tons of iron and steel by corrosion and consequent removal of material rendered unserviceable. Taking into account the cost of protecting the material, Sir Robert estimated the aggregate annual loss due to the effects of corrosion at well over 500,000,000*l.* These figures give an idea of the extreme gravity of corrosion and emphasize the very great value of the work being carried out by many scientists with a view to minimising its effects, a complete solution of the problem appearing to be quite out of question so far as can now be ascertained. This vexed problem in all its various aspects is dealt with by Mr. U. R. Evans in his book "*The Corrosion of Metals*," now published by Messrs. Edward Arnold and Co., London (price 14*s.* net). The author, and very rightly so, states that the study of the "making of metals" appeals directly to a comparatively limited number of persons, whilst that of the "unmaking of metals" concerns the whole community in every land. His book, for the purpose of this brief note, may be divided into two parts, that which reviews in detail the extremely varied occurrences of corrosion, and that dealing with the mitigation of the evil. Special chapters relate to this second part, but, as Mr. Evans states, the intelligent application of the principles which he explains in detail when reviewing the occurrences of corrosion may go far towards lessening the evil. He classifies the direct method for the restriction of corrosion under the three well-known headings, the preliminary treatment of the liquid, or atmosphere, causing the trouble; coating the metal with a protective layer and electro-chemical protection. A fourth method is to replace the metal being eaten away by some other material which can withstand corrosion without special treatment or protective cover. Mr. Evans is an authority on the subject and has contributed largely to the discussions on corrosion and its limitation at the meetings of the Institute of Metals, the last occasion being as we reported on page 379 *ante*. His book and the measures which he indicates will repay careful consideration and application.

Of recent years a tendency has appeared to use statistical methods in many classes of work that cannot be investigated completely or at all by experimental methods. Used with discretion, this practice may be of considerable value, particularly in suggesting directions for further investigation or possible explanations of such results as have been obtained by observation or experiment. It is, however, open to the danger that to apply a statistical calculus may be much easier than to interpret the meaning of the result, if, indeed, it should happen to have any evident meaning at all. The report just published by the Industrial Fatigue Research Board ("*The Function of Statistical Method in Scientific Investigation*," by C. Udny Yule, C.B.E., M.A., F.R.S., H.M. Stationery Office, 6*d.* net) gives a clear and timely caution against this danger, which may be expected to be of the more value by reason of the author's distinguished position in statistical investigation. Mr. Yule remarks that the common gibe that anything can be proved by statistics is less true than its exact contrary. It is, indeed, in his view seldom that statistics can give complete proof of anything. They may show that the facts are consistent with a hypothesis, but are less likely to prove that no other hypotheses would be equally applicable. It should, therefore, always be the aim of an experimenter to reduce to a minimum the weight of statistical methods in his investigation, and, in particular, he must not only require the average of a sufficient number of observations before arriving at a conclusion, but must see that this number bears a suitable relation to the extent to which the observations differ among themselves. In technical terms, he must think not so much of the observation, or even of the average of a number of observations, but of the frequency distribution. Nothing is more common than to see inferences based on a series of observations, the differences between which are no greater than might be explained by the chances of sampling, and this sort of interpretation is the more attractive when it happens to fit in with a pre-conceived theory. The statistician must be prepared to adapt his methods freely to his problems, and to remember that the mere inanimate calculus which is all that the theory of statistics can give does not create objective facts. Cautions such as these could not well be expressed better than in Mr. Yule's suggestive report, and it is to be hoped that they will be borne in mind, not only by the investigator of the Board, which has recently decided to publish the report, but by other workers who might be disposed to use statistical methods without regard to their limitations. The subject of this book is also dealt with in our leading article (page 709).

BOOKS RECEIVED.

Die Kommutatormaschinen für einphasigen und mehrphasigen Wechselstrom. By Dr. Ing. e.h. M. SCHENKEL. Berlin and Leipzig: Walter de Gruyter and Company [Price 10·50 gold marks.]

Canada. Department of Mines. Mines Branch No. 625. *Bituminous Sands of Northern Alberta.* By SIDNEY C. ELLS. Ottawa: F. C. Acland. [Price 25 cents.]

Modern Practical Joinery. A Comprehensive Treatise on the Practice of Joiner's Work by Hand and Machine. By GEORGE ELLIS. Fifth edition revised and enlarged. London: B. T. Batsford, Limited. [Price 45*s.* net.]

Talks on Town Planning. By H. V. Lanchester. London: Jonathan Cape Limited. [Price 4*s.* 6*d.* net.]

University of London. University College Calendar, 1924-25. London: Taylor and Francis.

Measurements of the Velocity Distribution in the Boundary Layer along a Plane Surface. By B. G. VAN DER HEGGE ZIJNEN. Delft: J. Waltman, Jr.

Transactions of the Institution of Civil Engineers of Ireland, Vol. XLIX, November to May, 1923. Dublin: Offices of the Institution.

Aeronautical Research Committee. Reports and Memoranda. No. 892. *Experiments with a Family of Airscrews.* Part III. *Analysis of the Family of Airscrews by Means of the Vortex Theory and Measurements of Total Head.* By C. N. H. LOCK, M.A., and H. BATEMAN, B.Sc. [Price 2*s.* net.] No. 904. *Report on Further Investigations of the Effect of Sunlight on Aeroplane Fabric* (*Part* 2). By W. G. GLENDINNING, B.A., B.Sc., and J. E. RAMSBOTTOM, D.Sc., Ph.D. [Price 6*d.* net.] London: His Majesty's Stationery Office.

The Microscope. Part II. By CONRAD BECK. London: R. and J. Beck, Limited.

The Technology of Water. By ALAN A. POLLITT, M.Sc. London: Ernest Benn, Limited. Price 6*s.* net.

Sulphuric Acid Concentration. Vol. I. *By Hot Gases.* By P. PARRISH, A.I.C., and F. C. SNELLING. London: Ernest Benn, Limited. Price 6*s.* net.

Organisation of Production. By JOHN W. CURTIS. London: Ernest Benn, Limited. Price 6*s.* net.

Crushing and Grinding Machinery. By HARTLAND SEYMOUR. London: Ernest Benn, Limited. Price 6*s.* net.

The Screening and Grading of Materials. By J. E. LISTER, Wh.Ex. London: Ernest Benn, Limited. Price 6*s.* net.

Cotton Cellulose: Its Chemistry and Technology. By A. J. HALL, B.Sc., F.I.C., F.C.S. London: Ernest Benn, Limited. Price 30*s.* net.

Das neue Russische Patentgesetz. By Professor I. J. HEIFETZ. Berlin: M. Krayn. [Price 4 marks.]

Moteurs a Combustion Interne. By PAUL DUMANOIS. Paris: J. B. Bailliére et Fils. [Price 60 francs.]

The Fatigue of Metals. By H. J. GOUGH, B.Sc. London: Scott Greenwood and Son. [Price 25*s.* net.]

CRUDE-OIL ENGINE SHUNTING LOCOMOTIVE.

THE heavy oil engine which, in a comparatively few years, has won such a commanding place in marine work has not up to the present achieved any considerable position in land transport. The remarkable economies of the engine, however, and its attractiveness for cases in which water supplies are difficult have resulted in many efforts being made to develop a satisfactory heavy oil engine locomotive, and work in this direction is now going on in many parts of the world. If one may judge by their achievements in the past it is probable that not the least important work of this kind is that which is being carried out by the Swiss Locomotive and Machine Works of Winterthur, Switzerland, and much interest is likely to be taken in the recently developed crude-oil engine shunting locomotive of the firm which is illustrated in Figs. 1 to 10 on the two following pages. We are indebted to Messrs. Bernard Holland and Co., of 17, Victoria-street, Westminster, the British representatives of the firm, for the particulars of this interesting machine.

The locomotive is built for standard gauge and is carried on two axles with coupled wheels as is clearly shown in Figs. 1 and 4. The wheel base is 2 metres. The main frame is of simple construction consisting of two plate longitudinals effectively cross-stayed and supported from the axle boxes on leaf springs. The machine is fitted with a 3-cylinder, 4-cycle crude oil engine of 80 h.p. running at 450 r.p.m. A gear box is fitted giving speeds of 5, 9½, 15 and 22 miles an hour, the drive at all speeds and on reverse being through an oil-immersed friction clutch. Any speed may be thrown in suddenly without shock or any danger of injury to the vehicle or engine. Shoe brakes operated either by a counter-weighted handle or by compressed air operate on all four wheels. The locomotive may be driven by one man. The tractive power at 5 miles an

CRUDE-OIL ENGINE SHUNTING LOCOMOTIVE.

CONSTRUCTED BY THE SWISS LOCOMOTIVE AND MACHINE WORKS, WINTERTHUR, SWITZERLAND.

Fig. 1.

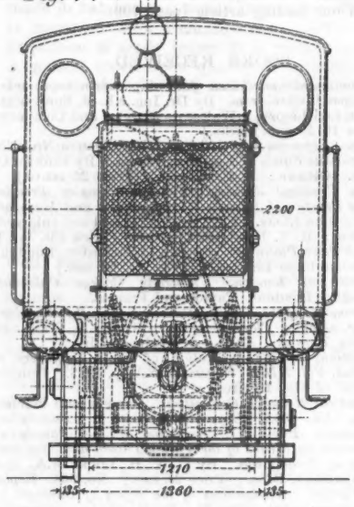


Fig. 2.

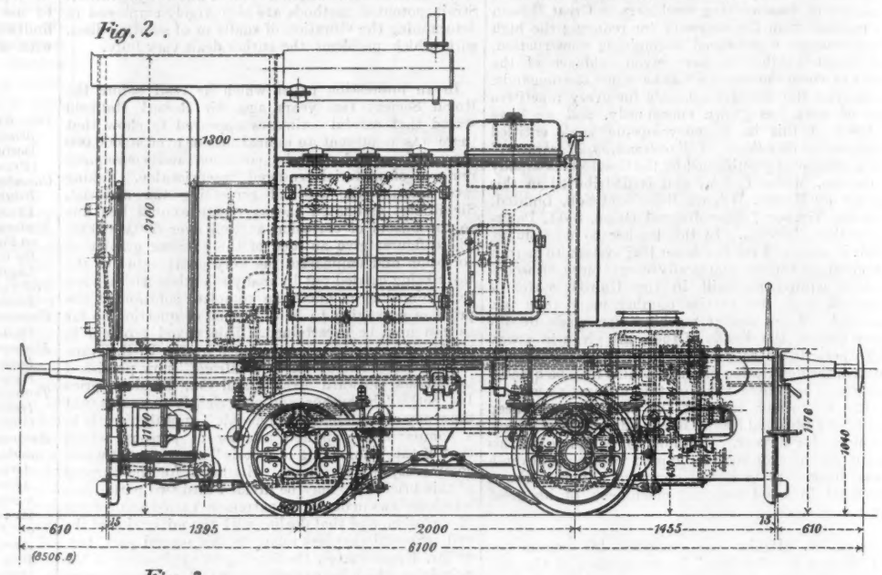
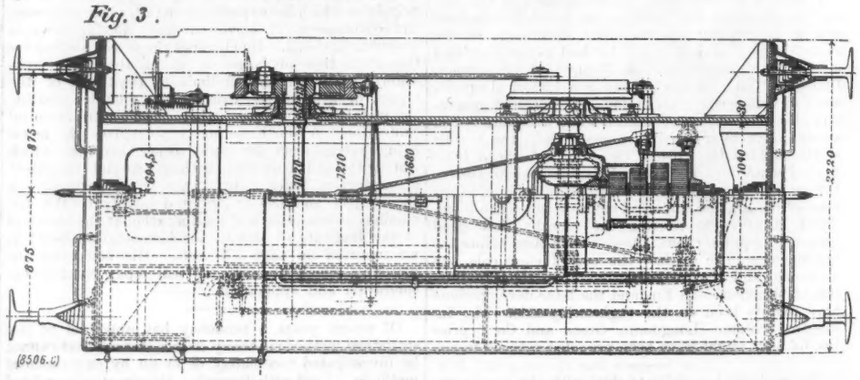


Fig. 3.



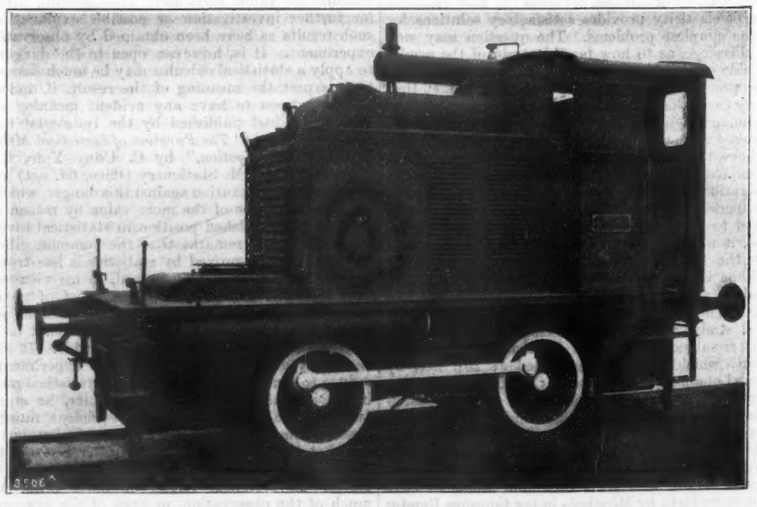


FIG. 4. GENERAL VIEW OF LOCOMOTIVE.

hour is 5,200 lb., and the weight of the machine empty is 5 tons, and in working order 5¼ tons.

The engine which is fully illustrated in Figs. 5 to 8, works, as mentioned above, on the four-stroke cycle. It utilises airless injection for the fuel. The three cylinders are 230 mm. (9 in.) in diameter by 290 mm. (11·4 in.) stroke and the power developed at 450 r.p.m. is 80 brake horse-power. At this rating the piston speed is at the moderate figure of 855 ft. per minute and the mean pressure on a brake horse-power basis is only 65 lb. per square inch, so that the engine is not in any way over-rated. The whole of the design has been worked out in a very simple way. The requisite combustion chamber to ensure ready ignition and good combustion of the fuel is provided by fitting the inlet and exhaust valves on opposite sides of the cylinder head in a horizontal plane as shown in Fig. 8. This is a similar arrangement to that adopted with so-called "cold-starting airless injection" horizontal oil engines and has been previously successfully used also with small vertical Diesel engines. With valves of large size, objection might be raised to the possible wearing down owing to the horizontal position, but in such small sizes the arrangement is quite satisfactory and permits of an excellent combustion chamber form.

The fuel injection nozzle is centrally placed in the cylinder head and the starting-air non-return valve in the fore and aft plane. The air inlet valve is carried in a removable cage of normal design. The exhaust valve has a small renewable seat, and the valve and its seat can be withdrawn through the inlet valve cage port. Both valves are operated from the one camshaft, the inlet valve by a push rod and lever, as shown in Fig. 6. Separate castings are provided for the cylinder head and liner. The bedplate, crankcase and the three cylinders are made in one casting, the tension loads being taken by fitting through bolts from the top of the cylinder head to the bedplate. Weight has been economised wherever reasonably and commercially possible, so that the engine is light for the power developed. The piston is short, and has five rings near the top and one scraper ring at the bottom. The crown is of conical form to follow the shape of the combustion chamber. The design of the gudgeon pin, crankpin and main bearing follow orthodox lines. Forced lubrication is adopted throughout, the hollow connecting rod containing a pipe to lead the oil to the top end bearing. The camshaft is driven by spiral gearing from the flywheel end of the crankshaft, and at the opposite end of the engine water and oil pumps are situated as well as a small air compressor for replenishing the reservoir, from which air for starting the engine and also for operating the brakes is drawn. The circulating water is cooled by passing it through a motor-car type of radiator, which may be seen in Fig. 4. A fan, driven by belt from the flywheel, as shown in Fig. 5, draws a current of air through the radiator.

The engine crankshaft is connected to the main gear shaft through a pair of flexible couplings, which are mounted at each end of an intermediate shaft, inserted in line between the engine and gearshafts. The gear box is carried on bearings which embrace the leading axle and is suspended by a spring attachment at its forward end in the manner commonly employed for electric traction motors. Any of the four speeds is thrown into action by means of oil-operated and immersed couplings, which are carried in the gear wheels—one coupling for each speed. All gear wheels are always in engagement and there are no sliding arrangements of any kind. Any individual gear only drives, however, when its clutch is engaged. The arrangement of the clutches is shown in Figs. 9 and 10, Fig. 9 showing a clutch in the working position, and Fig. 10 when disengaged. As will be seen, each gear wheel is made in two parts in order that the internal clutch may be got into place. The two parts are screwed together and the wheels run free on the hubs of the internal clutch discs. The discs are

CRUDE-OIL ENGINE FOR SHUNTING LOCOMOTIVE.

CONSTRUCTED BY THE SWISS LOCOMOTIVE AND MACHINE WORKS, WINTERTHUR, SWITZERLAND.

Fig. 5.

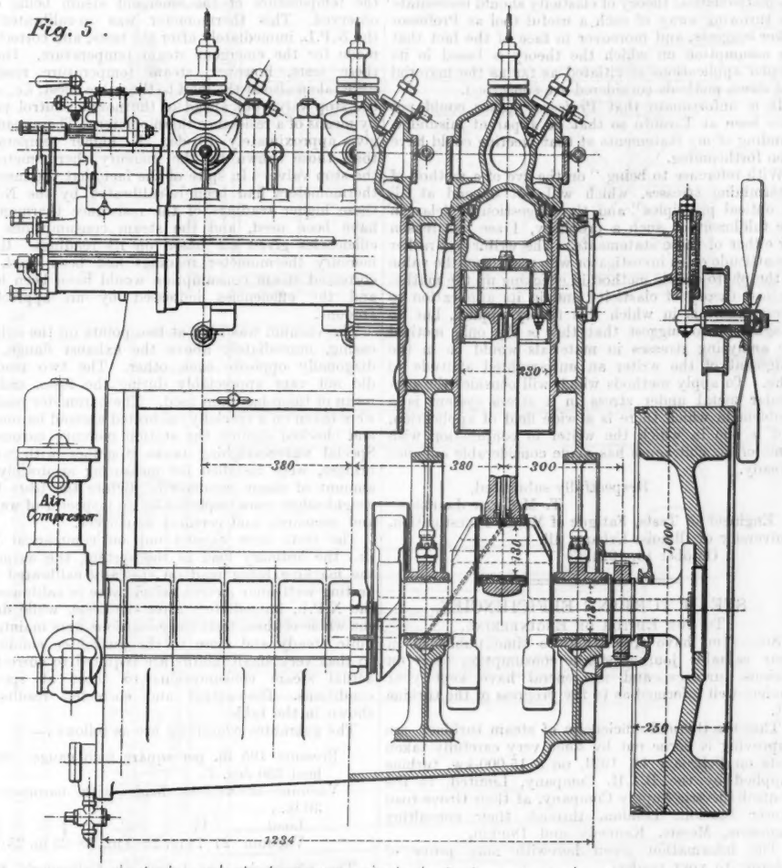


Fig. 7.

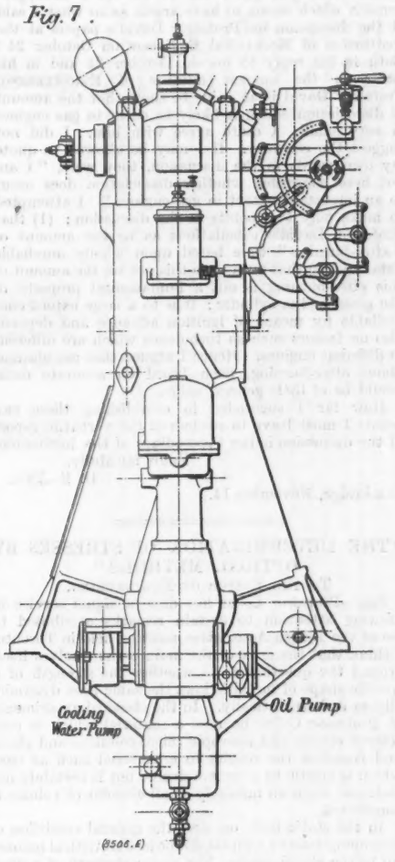


Fig. 6.

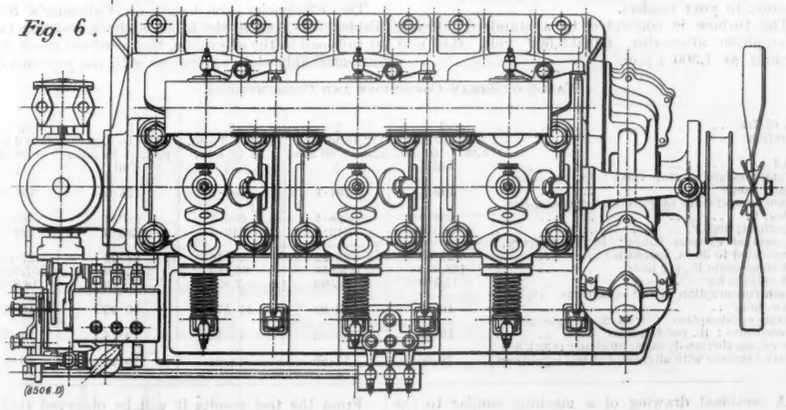
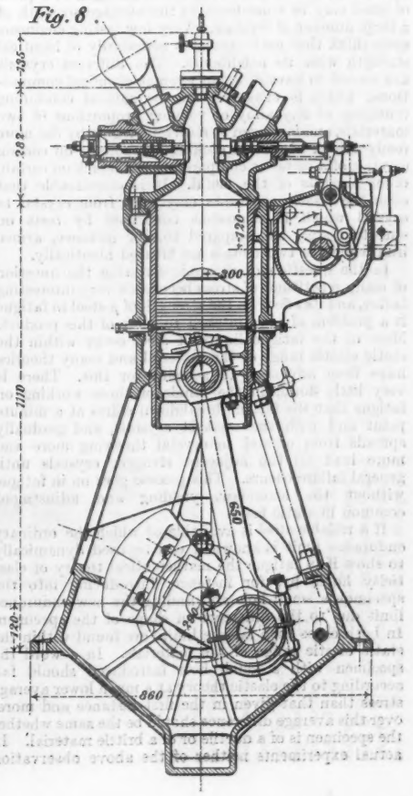
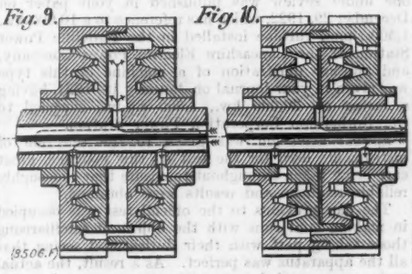


Fig. 8.



connected to the shaft by feather keys on which they can slide, so that when they are driven by the gear wheels they propel the shaft. The shaft has two internal longitudinal oil passages which communicate with the clutch through ports. The whole arrangement is continually filled with oil and when it is desired to engage a clutch, pressure is applied to the top passage in the shaft. This causes the two discs to move apart and engage the inner grooved faces of the gear wheel so that the wheel drives the clutch and, through it, the shaft. When the upper shaft passage is put to exhaust the clutch discs move apart under the action of the oil pressure, which is continually maintained in the lower shaft passage. They act on the opposite sides of the discs, as will be clear from the figures, and this tends to separate them. The clutches and the speeds of the locomotive are controlled by a four-way cock, operated by a driver's handle, and it will be clear that the very neat speed changing drive may be operated with absolutely no shock when the locomotive is running The pressure oil is supplied by a small tooth gear pump.

Fig. 9. *Fig. 10.*



The reverse gear which is incorporated in the axle drive also employs a similar type of oil-operated clutch, so that the locomotive when running may be instantly reversed without shock, and the clutches take up their drive so gently.

LETTERS TO THE EDITOR.

DISSOCIATION IN GAS ENGINES.

To the Editor of Engineering.

Sir,—Will you allow me to correct a misapprehension which seems to have arisen as to what I said at the discussion on Professor David's papers at the Institution of Mechanical Engineers on October 24? Both in his reply to me on October 24 and in his letter in the current number of Engineering, Professor David is at pains to show that the amount of dissociation which is likely to occur in gas engines is very small. I quite agree with him. I did not suggest the contrary. If I may be allowed to quote my own words in the discussion, they were, "I am not here concerned whether dissociation does occur to an important extent in gas engines." I attempted to make only two points in the discussion: (1) that Professor David's calculations as to the amount of "after-burning" were based upon wholly unreliable data, and (2) that even were this not so, the amount of this after-burning is not a fundamental property of the gases in the cylinder; it is to a large extent controllable by means of ignition advance and depends also on factors such as turbulence which are different in different engines. Hence I argued that calculations about after-burning, even based on accurate data, would be of little general value.

How far I succeeded in establishing these two points I must leave to readers of the verbatim report of the discussion in the Proceedings of the institution.

Yours faithfully,

D. R. Pye.

Cambridge, November 14.

"THE DETERMINATION OF STRESSES BY OPTICAL METHODS."

To the Editor of Engineering.

Sir,—Professor Coker has done a signal service in drawing attention to certain remarks attributed to me at the British Association meeting held in Toronto. I think that the crux of the main point resolves itself around the question as to whether the strength of a specific shape of metal follows the same laws dynamically as it does statically. In the classical experiments of Professor Coker he uses a material which is considered elastic and isotropic (nitro-cellulose and glass) and transfers the results to a material such as steel which is elastic to a certain degree but is certainly not isotropic when an infinitely small element of volume is considered.

In the static tests on steel the general condition of isotropesy follows without doubt in a statistical manner up to the elastic limit. The static strength of a piece of steel may be considered as the average strength of a large number of crystals. Very few testing engineers even think that each crystal is necessarily of identical strength with its neighbours. The different crystals are known to have different average chemical compositions, which is suggested by the natural combining tendency of any alloy of varying proportions of two materials, and is proven to a certain degree by the more ready attack of certain etching compounds on certain crystals of a metal as compared to the attack on certain other crystals of the metal. It is conceivable that even the elastic constants may vary from crystal to crystal which is somewhat confirmed by tests on eutectoid steel as compared to, for instance, armco iron when the two metals are treated identically.

In the question of dynamic stressing the question of many repetitions of stress becomes a very interesting factor, and its effect on the strength of a steel in fatigue is a problem of vital interest to users of this product. Most of the fatigue limits of steel occur within the static elastic range of the material and many theories have been advanced to account for this. There is very little doubt in the minds of those working on fatigue that the fatigue breakdown starts at a minute point and with the weakest crystals, and gradually spreads from crystal to crystal throwing more and more load on the adjacent stronger crystals until general failure occurs. This process goes on in fatigue without the attendant yielding and adjustment common in static tests.

If a reliable steel is available of which the ordinary endurance limit is known it can be used dynamically to show if in fatigue the mathematical theory of elasticity holds by, for instance, introducing into the specimen a small hole and finding the new endurance limit due to the difference in shape of the specimen. In both cases such fatigue limits are found within the static elastic range of the materials. In a word the specimen with a small hole introduced should fail according to the elastic theory at a much lower average stress than that given in the first instance and moreover this average difference should be the same whether the specimen is of a ductile or of a brittle material. In actual experiments neither of the above observation follows. In none of the several steels investigated have the ratios shown up as the elastic theory dictates, and the variations between ductile and brittle steels vary widely showing that the assumption of isotropy cannot be correctly made in such testing.

I fail to see why pointing out the limitations of the mathematical theory of elasticity should necessitate the throwing away of such a useful tool as Professor Coker suggests, and moreover in face of the fact that the assumption on which the theory is based in its simpler applications is vitiated as far as the material and stress methods considered are concerned.

It is unfortunate that Professor Coker could not have been at Toronto so that no apparent misunderstanding of my statements at that meeting could have been forthcoming.

With reference to being "on the eve of a method of determining stresses, which will not depend at all on optical principles" and the suggestion of delay in the fulfilment of such a prophecy, I see no reason for either of these statements. The writer has rather the attitude of an investigator who recognises the value of the photo-elastic method in checking up the mathematical theory of elasticity and in its application to stress analysis in which this theory applies, but to imagine or to suggest that this is the only method for analysing stresses in materials would be in the judgment of the writer an unwarranted attitude to take. To apply methods which will consider the particular metal under stress in a stress system is a problem in which there is a wide field of application, and is one in which the writer in conjunction with some of his colleagues has made considerable advance already.

Respectfully submitted,

T. McLean Jasper,

Engineer of Tests, Fatigue of Metals Investigation.
University of Illinois, Urbana, Ill.
October 15, 1924.

STEAM TURBINE EFFICIENCIES.

To the Editor of Engineering.

Sir,—You have from time to time published in your valuable journal steam consumption tests on various turbines, and in general have kept your readers well informed as to the progress of the turbine art.

That the thermal efficiencies of steam turbines are improving is borne out by some very carefully taken tests on February 12, 1924, on a 15,000-kw. turbine supplied by the B.T.H. Company, Limited, to the Central Electric Supply Company, at their Grove-road Power Station, London, through their consulting engineers, Messrs. Kennedy and Donkin.

The information given herewith may prove of interest to your readers.

The turbine is connected to a standard 50-cycle three-phase alternator, 6,000-6,600 volt, the unit running at 1,500 r.p.m.

A sectional drawing of a machine similar to the one under review was published in your paper on December 29, 1922, which has reference to a 10,000-kw. 1,500-r.p.m. turbine installed in the Radcliffe Power Station of the Lancashire Electric Power Company, and another illustration of a machine of this type was given in your journal on January 18, 1924, having a rating of 30,000 kw., 1,500 r.p.m., supplied to the Rotherham Corporation Power Station.

Special attention was given to the selection of instruments used for the test on this machine, great care being taken throughout to ensure that thoroughly reliable readings and results were obtained.

The day previous to the official test was occupied in making trial runs with the object of familiarising those taking part with their duties, and seeing that all the apparatus was perfect. As a result, the actual tests were carried out with the greatest possible smoothness.

The initial steam pressure at the stop valve was read on two special gauges, which were checked on a dead weight tester before the tests, and calibrated by the N.P.L. immediately afterwards. The mean of the latter corrected figures has been used. The actual difference in the readings, however, was a small fraction of a lb. per square inch.

The initial temperature at the stop valve was taken by means of a high reading mercury thermometer, the temperature of the emergent steam being duly observed. This thermometer was re-calibrated by the N.P.L. immediately after the tests, and corrections made for the emergent steam temperature. During these tests, however, steam temperature readings were taken also at the inlet to the valve chest, *i.e.*, after the stop valve but ahead of the nozzle control valve, by means of a resistance thermometer. These readings give approximately 10 deg. F. higher temperature than those shown by the mercury thermometer in the stop valve. In spite of the fact that the mercury thermometers had been re-calibrated by the N.P.L. these higher readings of the resistance thermometer have been used, and the steam consumptions and efficiencies given are based on its readings. If the mercury thermometer readings had been used, the corrected steam consumption would have been lower and the efficiencies increased by an appreciable amount.

The vacuum was read at two points on the exhaust casing, immediately above the exhaust flange, and diagonally opposite each other. The two readings did not vary appreciably during the tests, and the mean of them has been used. The barometer readings were taken on a specially calibrated aneroid barometer, and checked against the station mercury barometer. Special water-weighing tanks, together with weigh-bridges, were installed for measuring accurately the amount of steam condensed. Before the tests these weighbridges were inspected by an inspector of weights and measures, and certified as correct.

The tests were carried out on commercial load, *i.e.*, the ordinary load of the system, the output of the machine being read on specially calibrated integrating watt-hour meters, which were re-calibrated by the N.P.L. immediately after the tests, while during the whole of these tests the conditions were maintained quite steady and close to the guarantee conditions, so that very small factors are required to correct the actual steam consumptions to those at specified conditions. The actual and corrected results are shown in the table.

The guarantee conditions are as follows:—

Pressure 195 lb. per square inch gauge. Superheat 250 deg. F.
Vacuum at various loads with barometer at 30 in.:—

Load	1¼	Full.	¾	½
Vacuum	27·75 in.	28·0 in.	28·25 in.	28·5 in.

The efficiencies are based on Callendar's Steam Tables. As seen in the table, a check test was taken at full load in the afternoon, the corrected result being in remarkably close agreement with the previous test.

Table of Steam Conditions and Consumptions.

No. of Test	1	2	3	4	5
Duration	10.45 to 11.45 a.m. = 60 min.	12.15 to 1.15 p.m. = 60 min.	2.30 to 3 p.m. = 30 min.	3.30 to 4.30 p.m. = 60 min.	5 to 6 p.m. = 60 min.
Load	Full	¾	½	Full	1¼
Steam pressure at stop valve: lb. per square inch gauge	193·1	194·1	193·7	195·3	191·0
Steam temperature by resistance thermometer, deg. F.	634·9	628·4	635·1	620·3	623·3
Superheat, deg. F.	249·8	242·9	249·8	234·3	239·0
Vacuum at exhaust flange: inches mercury, corrected to 30-in. barometer	27·93	28·22	28·46	27·92	27·62
Net condensate lb. per hour	165,030	125,555	85,110	167,280	207,025
Net output, kw.	15,189	11,509	7,623	15,279	18,855
Steam consumption at test conditions: lb. per kw.-hour	10·87	10·91	11·17	10·95	10·98
Steam consumption corrected to guarantee conditions: lb. per kw.-hour	10·80	10·82	11·12	10·76	10·76
Percentage thermo-dynamic efficiency (efficiency ratio) turbine with alternator at test conditions	79·06	77·50	74·04	79·14	80·46

From the test results it will be observed that the best efficiency at full load is equal to 79·14 per cent., and at overload 80·46 per cent. These efficiency figures include all losses in turbine and alternator.

We estimate that the efficiency of the alternator is 96·5 per cent. at full load, and 97 per cent. at overload. Allowing for these efficiencies, the thermo-dynamic efficiency of the turbine alone becomes 82·01 per cent. at full load, and 82·95 per cent. at overload, which efficiencies are very satisfactory, and indicate progress in the art.

During these tests, Professor Callendar was taking inter-stage efficiency readings of the turbine in the high pressure end, and these figures also bear out as far as they go, the remarkably high efficiency obtained in this turbine. These tests were taken under the supervision of Messrs. Kennedy and Donkin, and have been approved by Sir Alexander Kennedy.

Yours faithfully,

F. Samuelson.

The British Thomson-Houston Company, Limited,
Rugby, November 14, 1924.

BATTERY OF DROP STAMPS WITH MULTIPLE IMPRESSION DIES.

CONSTRUCTED BY MESSRS. BRETT'S PATENT LIFTER CO., LIMITED, ENGINEERS, COVENTRY.

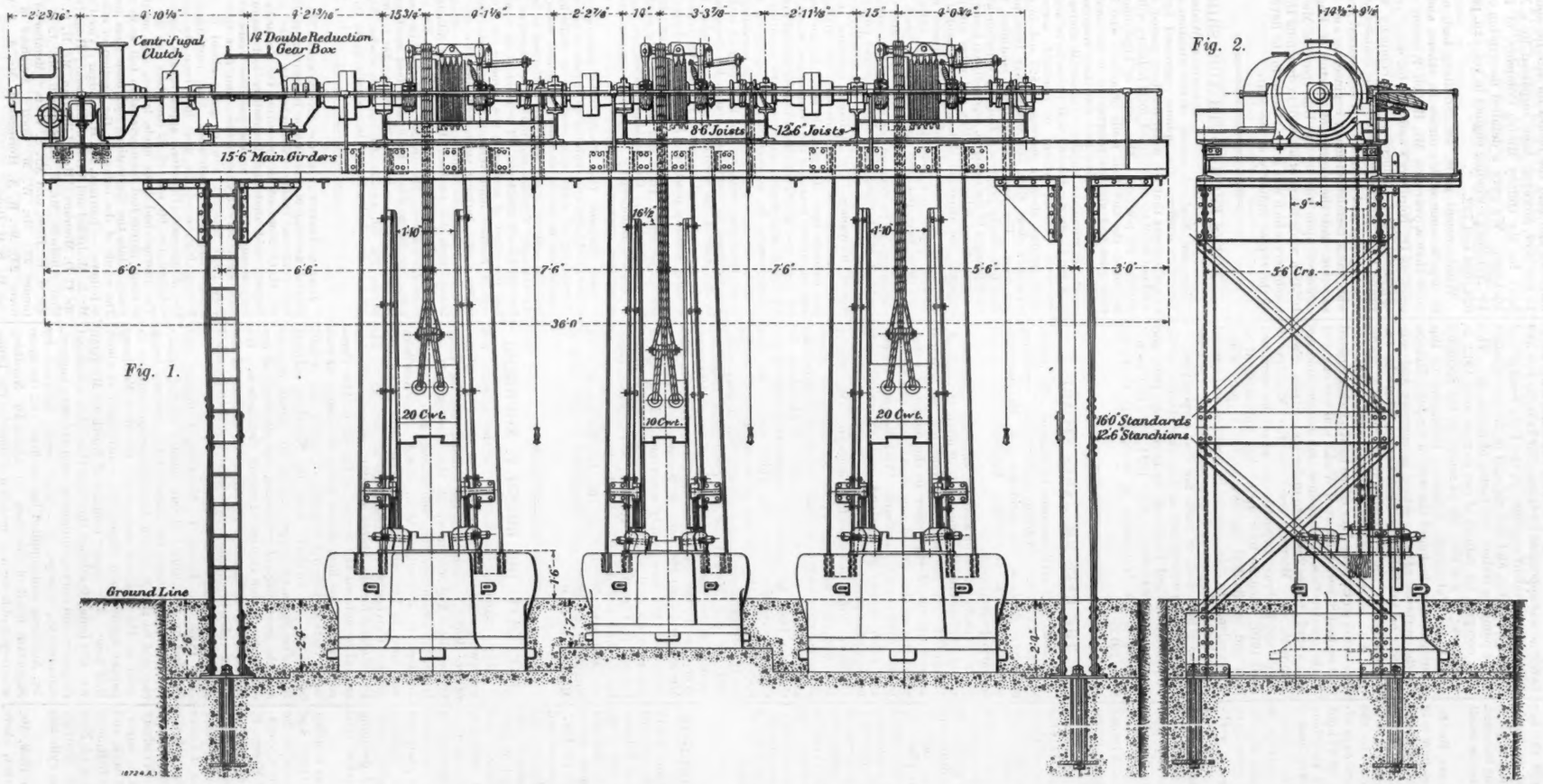


Fig. 1.

Fig. 2.

DROP STAMPS WITH MULTIPLE IMPRESSION DIES.

A VERY interesting development has recently been introduced by Messrs. Brett's Patent Lifter Company, Limited, of Coventry, in connection with a battery of drop stamps installed by them at the works of the Heatly-Gresham Engineering Company, Limited, at Letchworth. This battery is to be used for the production of parts of railway appliances, and the novelty of the installation consists in the arrangements made for the use of multiple-impression dies. With such dies some of the impressions are bound to be to one side of the centre, and the new form of stamp which Messrs. Brett's Patent Lifter Company have brought out is designed with particular regard to the eccentricity of the blows and with a view to taking proper care of the resultant shock to the guides.

In the ordinary form of stamp the guides for the tups have adjustment at the base by means of screwed pins and nuts, and the upper die is accurately located by these means over the lower, fixed to the anvil. Anything but a central resistance in stamping with this arrangement transmits considerable shocks to the guides, and the pins and nuts require constant attention. The new pattern of stamp provides a much more rigid and effective structure, so that eccentricity of the blow is not so objectionable. The new battery referred to above is illustrated in Figs. 1 and 2 herewith, and Figs. 4, 5 and 6 on page 708, and consists of one 10-cwt. and two 20-cwt. stamps. The difference between the new and former designs is brought out by means of Fig. 3, on page 708, which illustrates a battery of stamps arranged as described above for single-impression dies.

In Messrs. Bretts' new design the tup guides are carried on stiff columns of rolled-steel sections, and the latter are held rigidly in the structural framework at the top and the anvil block at the bottom, no provision being made for their adjustment. Guides are carried on the inner faces of these columns and are tapered, the columns being slightly spread towards the base, as will be seen in Fig. 1. The vertical setting of these guides controls the exact position of the tup and upper die. It is obvious that the raising of one taper guide and lowering the other will throw the line of the falling tup over to one side or the other, while the distance apart of the faces can be readily suited to the dimensions of the tup. The guides are backed for their whole length by the rigid columns, to which, after setting, they are clamped, the vertical adjustment being secured by means of vertical screws and nuts at the lower end, in conjunction with brackets on the columns. These parts are relieved of all strain after the setting is done and they do not have to withstand any such jars as occur in the case of the adjusting pins and nuts of the ordinary form of stamp. It may be noted that any failure of the clamping or setting devices involves no risk, as the direction of the taper would prevent jamming. This arrangement, it will be appreciated, is much more rigid and more easily maintained in precise adjustment than the usual system, and more accurate work results, with less attention, once the correct setting has been secured. The details of the guides and adjusting arrangements can be clearly followed in Fig. 1, and are well shown in the view reproduced in Fig. 4.

In the battery under notice the dies are cut with three impressions. To one side is a roughing or initial forming impression. On the other side is a second impression for carrying the work a stage farther. In the centre is the finishing die. The use of such dies greatly expedites the work, which can be finished

completely without the stamper moving from his position. There is no loss of time in moving from the dummying tools to the finishing stamp and the bar remains under the one hammer from start to finish. There is further, the advantage of the saving of plant and room by the elimination of the dummying hammer, while finishing the work in three stages is said to result in a considerable saving of metal.

As regards the lifting gear, these are of Messrs. Bretts' standard friction-driven type. The gear is shown in Figs. 5 and 6. The lifters are electrically driven through double-reduction totally-enclosed gearing, the motor and gear-box being seen in Fig. 5. The gears run in an oil-bath. The connection of the motor to the first gear-box shaft is by means of a centrifugal expanding clutch, so that the motor can be started up without load. The clutch also provides a means of absorbing undue shocks, as it will slip slightly if a heavy load is suddenly applied, as, for instance, when, as is sometimes unavoidable, the tup is suddenly arrested in falling, before the blow is delivered. Though a little more costly than open gears, the enclosed gears have the further considerable advantage of silence in working. The lifter gear is shown in Fig. 6. It is very robust and simple in construction. The main friction drum is solid and finished with multiple grooves to take the friction blocks. The lifting arms are drop forgings with journals on the shaft lined with phosphor bronze bushes. The main shackle or yoke to which the tup rope is connected, is hinged at one end to one of the lifting arms, and at the other passes between jaws on the end of the second arm, as will be seen in the illustration. To this shackle or yoke the friction block or blocks are connected, the number varying with the size of the hammer. The action of these blocks is controlled by a curved lever hinged to one arm and connected by short links to the yoke. The curved lever is operated by means of a rope coiled round a winch drum on the shaft. On the application of downward pressure to the lever by pulling on the rope the friction blocks engage with the drum and the arms are swung round, the tup being thereby lifted. Quick release is ensured in the first place by an adjustable spring acting on the tail of the curved lever, and lifting it as soon as the rope pull is released, and further by a weight suspended from the end of a small cord, acting on the control rope. The action of the weight is to relieve the rope positively of any pull as soon as released by the operator, thus freeing it on the winch drum, and eliminating all tendency to drag. The friction blocks are lined with a special "ferobestos" material, exclusively manufactured by Messrs. Ferodo, Limited, of Chapel-en-le-Frith for the hammers of Messrs. Bretts Patent Lifter Company, Limited.

THE LATE MR. JAMES SMITH MORRISON.

We regret to announce the death of Mr. James Smith Morrison, M.Inst.C.E., M.I.Mech.E., which occurred suddenly on Monday last at his residence at Eltham Park, S.E. 9. Mr. Morrison, who was 59 years of age at the time of his death, received his early training with Messrs. P. and W. McLennan, of Glasgow, where he was occupied for five years from 1882 to 1887. Subsequently he was engaged as a draughtsman and erector with Messrs. Arrol Brothers, of Glasgow, his next engagement being as chief draughtsman to the Stockton Forge Company. Towards the end of 1891 he joined the staff of the Great Eastern Railway and was engaged on designs for widening and extension works, mainly in the London area, until 1896. In that year he was appointed to the staff of the Director of Works at the Admiralty, being occupied in the design of jetties, wharves, slipways, &c., for about a year, and then receiving the appointment as resident engineer at Devonport Dockyard. Here he was engaged, under Major Kenyon, R.E., in the supervision of dredging operations, dock-wall construction, and other civil engineering work.

He left Devonport for Pembroke Dockyard in 1899, acting as Civil Engineer in Charge of that yard and carrying out a number of new works in addition to the usual repairs and maintenance. Leaving the Government service in 1901, he joined the staff of Messrs. S. Pearson and Son as an engineer and was first engaged on the tunnelling work in connection with the construction of the City and Great Northern Railway. After being occupied with the construction of the east arm of Dover Harbour, and later as engineer and manager of the Plymouth Outfall Works, Mr. Morrison was sent to America by Messrs. Pearson in connection with railway tunnelling contracts. He afterwards acted as superintendent engineer on the East-River Tunnel work, and then as resident engineer and manager on the Baltimore Dock contract for Messrs. Suare and Triest of New York. His work in connection with this contract consisted mainly in the sinking of foundation cylinders and dredging operations.

Rejoining the staff of Messrs. Pearson in 1909, Mr. Morrison proceeded to their Para Dock contract, where he acted as engineer for construction work and took charge of block-setting operations and foundation work. Later, he was appointed by Messrs. Sir Douglas Fox and Partners as resident engineer on the Para Sewage and Drainage Scheme, and was engaged in the construction of the pumping station, the laying of mains, &c. This work occupied the subject of our memoir until 1912, in which year he was sent out to report on the Secondee and Accra Waterworks Scheme. Returning to this country in 1914, he joined the staff of Sir John Jackson on the outbreak of war, acting as engineer and submanager on the Salisbury Plain Camps, where he was responsible for the construction of railways, roads, huts, &c., as well as for drainage works. He was afterwards sent by the War Office to Woolwich Arsenal as Assistant Superintendent of Works, and was engaged on the construction of magazines and danger buildings with a staff of over 2,000 men under his control. From Woolwich, Mr. Morrison went to the Ministry of Munitions Railway Department, where he remained until 1919, when he took up his last appointment as civil and mechanical engineer to the Cyprus Mines Corporation. In this capacity he designed and erected a pier for loading ore at Cyprus and also surveyed the site for a new dock or basin for that corporation.

Mr. Morrison was elected an Associate Member of the Institution of Civil Engineers in December, 1899, and became a full member in May, 1921. He had been a Member of the Institution of Mechanical Engineers since 1913.

THE LATE MR. JAMES STUART.

A prominent civil engineer in Glasgow, Mr. James Stuart, of Messrs. Warren and Stuart, consulting engineers, died, at his residence, 14, Marlborough-avenue, Partick, on Friday, November 14, in his seventy-third year.

Mr. Stuart was educated at Glasgow University, and in 1877 entered the office of Sir William R. Copland, M.Inst.C.E. In the six years following, he acquired a great amount of experience in the design of waterworks, for in that period new works were constructed by Sir William at Sandbank, Clackmannan, Girvan and other places in Scotland, and extensions were made to the existing works at Cambuslang, Hamilton, Dalmuir, Kirkintilloch and Springburn. Mr. Stuart also designed sewerage works for many of these districts, constructed a tidal basin at Dumbarton, and the timber pier on the Gareloch at Shandon. In the year 1883, he joined the engineering staff of the Clyde Navigation Trust, in which service he was responsible for the erection of extensive goods sheds, for the strengthening and reconstruction of quay walls, and for the foundations for rail-bourne travelling cranes at the docks to lift loads of up to 130 tons. When he left the service of the Clyde Trust, in 1893 Mr. Stuart joined Mr. John A. Warren in partnership, and since then was mainly concerned with design of sewerage disposal schemes and water-supply undertakings in Lanarkshire, Ayrshire, Stirlingshire, Dumbartonshire and Argyllshire. Mr. Stuart was elected an Associate Member of the Institution of Civil Engineers in 1898, and transferred to the class of Member in 1900.

THE LATE DR. BRUNO V. NORDBERG.

Many engineers on this side of the Atlantic will learn with regret of the death, on the 30th ultimo, of Dr. Bruno V. Nordberg, the founder, and for many years the chief engineer, of the Nordberg Manufacturing Company, the well-known firm of engine builders, of Milwaukee, Wis., U.S.A. Dr. Nordberg was born in Finland in 1857, and after graduating at the University of Helsingfors at the age of 21, left Finland for the States in 1880. Shortly after his arrival he entered the service of the E. P. Allis Company, one of his first duties being the design of two large vertical blowing engines, of which one is still in service. At an early date, Dr. Nordberg realised the advantages of poppet valves for steam engines and the possibility of improving the efficiency of the engine by better control of steam distribution. He consequently designed a governor for engines of the poppet-valve type, which gave what was then regarded as a very high degree of economy.

In 1886, the Bruno V. Nordberg Company was founded by the subject of our memoir for the manufacture of governors, the name of the concern being changed to the Nordberg Manufacturing Company in 1890 as the business extended; the first Nordberg poppet-valve steam engine was constructed at about that time. The copper country of Northern Michigan was also being developed then and this led to a demand for power and mining equipment such as hoists, engines, compressors, stamps, &c., which were designed by Dr. Nordberg and supplied by the firm. Of the more important plant of this class for which Dr. Nordberg was responsible we may mention a hoist for the Tamarack Mining Company which had a drum 25 ft. in diameter and held the record for size for some years. It has now, however, been surpassed by a Nordberg hoist for the Quincy Mining Company, of Hancock, Michigan. We gave a detailed description of one of Dr. Nordberg's winding engines in vol. cxii, pages 565, 628, 694 and 752.

Within recent years, Dr. Nordberg had, naturally, to depute some of his duties to others, and, rather more than a year ago, Mr. Rudolf Wintzer, who had acted as Dr. Nordberg's assistant for many years, was appointed chief engineer to the company with Mr. Bruno V. E. Nordberg, a son of the founder, as executive engineer and assistant. The deceased gentleman, who was a member of many engineering and scientific societies, had the degree of Doctor of Engineering conferred upon him by the University of Michigan in 1923, in recognition of his skill in designing the special machinery which was a vital factor in the development of the copper industry of the State.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—A survey of the situation in South Yorkshire confirms the opinion expressed by leading manufacturers that the worst has been passed, and that if labour troubles are avoided, local industry will steadily improve its position. This spirit of hopefulness is reflected in the fact that trade organisers who for some time past had allowed reserves to lie dormant at the bank, are now bringing into use these resources in an effort to stimulate buying. Industrial shares in this area are in strong demand and prices have accordingly increased. Unemployment in Sheffield, according to latest returns, shows a decrease of 825 and, in addition, some 525 short time operatives have been placed on full time. The heavy steel trade continues to make slow but steady progress. Railway departments report an expansion in the demand, especially on home account. Contemplated schemes in this and other countries are engaging the attention of local makers, and if suitable prices can be arranged there is no reason why this district should not benefit. Makers of axles, wheels and tyres have put into operation more plant in order to meet the increased call from collieries and transport companies. The demand for shipbuilding steel, marine castings, and turbine parts shows a slight improvement, and it is believed this section will steadily regain its former buoyancy. The Midlands continue to be the chief purchasers of automobile steel and fittings; output exceeds that of a month ago. In the implement and machinery branches the Colonies and South America are good customers, especially in agricultural machinery. Electrical and textile engineers are awaiting further developments in connection with overseas schemes. Colliery development in this district is providing makers of pit head gear, winding and haulage gear with orders. The proposal to erect steel houses has been welcomed in this district, for should it prove successful, the steel trade generally will benefit. The lighter trades are in a fairly healthy position. Makers of all classes of tools are doing a growing volume of work on both home and foreign account. There is a strong call for garden tools by the Colonies. The building trades are big buyers of general ironmongery, stoves, rain-water goods and other steel products.

South Yorkshire Coal Trade.—The position generally shows no change, and inability to dispose of big surpluses is resulting in short time working at collieries. Best steams are in active demand for inland consumption, but the amount going away for shipment is far below the average. Cobbles and nuts have improved slightly, but slacks are unaltered. The recent cold weather has had the effect of increasing the demand for house coal, and a further improvement is expected. Output of foundry and furnace coke continues to exceed the demand. Gas coke is firm. Quotations:—Best branch handpicked, 32*s.* to 35*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 27*s.* to 32*s.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 22*s.* 6*d.* to 25*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 20*s.* 6*d.* to 23*s.*; Derbyshire hards, 20*s.* 6*d.* to 22*s.* 6*d.*; rough slacks, 9*s.* 6*d.* to 12*s.*; nutty slacks, 9*s.* to 11*s.*; smalls, 5*s.* to 7*s.* 6*d.*

Junior Institution of Engineers.—The annual general meeting of the Junior Institution of Engineers was held on Friday, November 14. The chairman, Mr. C. O. Mourant, in presenting the Council's Annual Report, said that the Institution had maintained a very steady position in the past few years, which had been of a very trying nature, and that there was a very good prospect now of going ahead in point of membership and usefulness. One particularly satisfactory feature of the year had been the success of the Engineers' Register, appointments having been obtained for 60 out of 92 members on the register. The journal had been made larger, and nearly twice as many papers had been printed in full as in previous years, while the illustrations had been more numerous. The result of the ballot for the election of officers was as follows:—Chairman, Mr. H. J. Edgar; Vice-Chairmen, Mr. L. M. Jockel and Mr. A. J. Simpson; Hon. Treasurer, Mr. C. O. Mourant; Hon. Librarian, Mr. H. P. Wright; Hon. Auditors, Mr. F. E. Squirrell, Mr. J. H. Seddon, Mr. S. H. Hole, and Mr. S. Potts; Member of Council (under 23), Mr. W. M. Good; Members of Council (over 23), Mr. R. A. Horregaard, Mr. A. J. Wheeler, and Mr. S. H. Hole.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Gradual growth of business in Cleveland pig-iron is gratifying and satisfactory. Steady increase in demand promises to justify early enlargement of output, as makers' stocks are fully disposed of and current production is barely sufficient for needs. Buying is mostly for home purposes, but the outlook as regards export trade is rather better and a few overseas sales have been made. Quotations continue on the upward curve, and up to the present customers have not hesitated to follow the rise, but as it is fully realised that much further advance might check buying, makers are apparently content to book forward contracts at round about ruling rates. Quite a number of orders for delivery over periods next year are reported to have been placed. No. 1 is 87*s.*; No. 3 g.m.b., 82*s.*; No. 4 foundry, 81*s.*; and No. 4 forge, 80*s.*

Hematite.—Considerable activity continues to characterise the East Coast hematite branch. Makers' stocks, though still heavy, are being substantially drawn upon, and with the strengthening statistical situation values are more than fully maintained. Several parcels have been sold for despatch to foreign destinations, and home demand promises to increase. Nos. 1, 2 and 3 are up to 89*s.*; and No. 1 is now quoted 89*s.* 6*d.* to 90*s.*

Foreign Ore.—There is a firmer feeling in foreign ore, and sellers anticipate further sales. Market rates are based on best rubio at 22*s.* 6*d.* c.i.f. Tees.

Blastfurnace Coke.—Durham blastfurnace coke, of good medium quality, is still obtainable at 25*s.* delivered to local consumers' works, supply being plentiful, but demand is a little better, and some advance would cause no surprise.

Manufactured Iron and Steel.—There are more inquiries circulating for manufactured iron and steel, and with Continental competition nothing like so keen as it has been, the position has decidedly improved. Whilst sales generally are not on an extensive scale, a few fairly good orders are understood to have been secured in several departments. Among the principal market quotations are: Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel boiler plates, 13*l.*; steel ship, bridge and tank plates, 9*l.* 15*s.*; steel angles, 9*l.* 10*s.*; steel joists, 9*l.* 10*s.*; heavy steel rails, 9*l.*; fish plates, 12*l.* 10*s.*; black sheets, 12*l.* 10*s.*; and galvanised corrugated sheets, 17*l.* 10*s.* to 18*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Development in the steel trade of Scotland is very slow and any change for the better is hardly noticeable yet. It would almost seem as if the improvement about which so many have been speaking of late was going to take some time to reach the steel industry. Inquiries are better again and from their number and the tonnage represented, the inference is that there is quite a lot of business to place. The current demand, however, is by no means heavy in any department, and much of the plant is at present lying idle. The only branch which is really well employed is that for black sheets, and the conditions have varied practically nothing over the week. Heavy gauges are very flat, but light and galvanised sorts are in good demand, with a respectable tonnage of the latter going overseas. Prices have not altered since last report, and the following are the current quotations: Boiler plates, 13*l.* per ton; ship plates, 9*l.* 15*s.* per ton; sections, 9*l.* 10*s.* per ton; and sheets, $\frac{1}{4}$ in. to $\frac{1}{8}$ in., 12*l.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—There has been no change in the state of the malleable iron trade of the West of Scotland during the past week, and hand-to-mouth conditions are all too general. Buyers are difficult to find, and few there are who care to place orders for more than their actual immediate requirements. With business so poor and the outlook rather doubtful, the prospect of a revival in the industry in the near future is not bright. "Crown" bars are quoted, without change, at 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—A good tone continues to prevail in the Scottish pig-iron trade, and over the week a fair tonnage has been booked for forward delivery. The demand for current requirements is not heavy and stocks on hand are still quite ample to meet the needs of all for the meantime. Prices are without change, and are quoted as under: Hematite, 4*l.* 15*s.* per ton, delivered at the steel works; foundry iron, No. 1, 4*l.* 15*s.* per ton, and No. 3, 4*l.* 10*s.* per ton, both on trucks at makers' works.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ended last Saturday, November 15, amounted to 1,549 tons. Of the total, 960 tons went overseas and 589 tons went coastwise. For the corresponding week of last year the figures were 2,045 tons to foreign ports and 138 tons coastwise, making a total shipment of 2,183 tons.

Shipbuilding.—Messrs. Henry Robb, Limited, Leith, have secured an order from the Union-Castle Mail Steamship Company to build a powerful screw tug for service at Port Elizabeth, South Africa. This will be the first vessel to be laid down at the firm's new Victoria yard at Leith. Messrs. McKie and Baxter, engineers, Govan, have booked some contracts which include two vessels for the St. Lawrence, the hulls of which will be sub-contracted with Clyde shipbuilding firms. The vessels are for vehicular and passenger service and each will accommodate 50 motor-cars. As a sub-contract Messrs. McKie and Baxter are to provide the machinery for two oil tank steamers which are being built on the Clyde for Messrs. Alfred Holt and Co., Liverpool.

Locomotive Contracts.—The New Zealand Government has accepted the tender of the North British Locomotive Company, Springburn, for 35 locomotives, the total cost of which will be about 225,000*l.* The same firm recently fixed up orders for another 15 locomotives, so that the outlook for their workers is considerably better than it was.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The Customs returns of the volume and value of coal exports from the principal South Wales ports in October make bad reading so far as the outlook for the Welsh coal industry is concerned. Though there was an extra working day in October as compared with September, the volume of trade was reduced by 55,620 tons and the total of 1,968,763 tons was only lower in one month of the year. The value of the shipments at 2,437,326*l.* was lower by 85,176*l.* and the average realised f.o.b. price per ton at 24*s.* 9*d.* was down by 2*d.* At Cardiff, shipments were reduced and the realised price at 24*s.* 1*d.* showed a drop of 4*d.* per ton. Exports from Newport were increased but the average value was also 4*d.* lower. Shipments from Port Talbot were, however, increased, as also was the average price, by 1½*d.* per ton, and though the volume of trade was less at Swansea, the average price was increased by 10½*d.* per ton due to a continued good demand for anthracites at rising prices. The volume and value of the shipments at each port in October are shown below.

From—	*October*, 1924. Tons.	£	Per Ton. *s.*	*d.*
Cardiff ...	1,177,466	1,419,395	24	1
Newport ...	365,434	430,400	23	7
Port Talbot	160,227	183,247	22	10½
Swansea ...	265,636	404,284	30	4½
Totals ...	1,968,763	2,437,326	24	9

Large coal shipped in October amounted to 1,307,729 tons, valued at 27*s.* 11*d.* per ton, or 3*d.* less than in September; that of through totalled 33,867 tons at 20*s.* 10½*d.* per ton, a reduction of 2½*d.*; while small coal shipments aggregated 627,167 tons at 18*s.* 5*d.*, a drop of 3½*d.* per ton. Anthracite coal shipped from Swansea amounted to 186,597 tons, or 31,413 tons less than in September, but the average realised price at 34*s.* 7½*d.* per ton was 2*s.* 1½*d.* higher. Large anthracite averaged 43*s.* 5*d.*, or 10*d.* more than in September, and small 24*s.* 9*d.*, an increase of 1*s.* 4*d.* Steam coal values, however, were generally lower. Large shipped from Cardiff, for instance, averaged 26*s.* 10*d.*, compared with 27*s.* 1*d.* in September and 28*s.* 5*d.* in April, while small realised 16*s.* 9*d.* against 17*s.* 2*d.* in September and 19*s.* 8*d.* in April. Steam large exported from Swansea averaged 25*s.* 8*d.* in October compared with 28*s.* 1*d.* in March, and small 16*s.* 9*d.* against 17*s.* 7*d.* in September and 18*s.* 5*d.* in May.

Iron and Steel.—Exports of iron and steel goods from South Wales in the past week amounted to 9,574 tons, compared with 6,042 tons in the previous week. Shipments of tinplates totalled 6,669 tons against 3,982 tons; blackplates and sheets, 918 tons against 912 tons; galvanised sheets, 1,467 tons against 809 tons; and other iron and steel goods to 520 tons against 339 tons. Though business is by no means brisk, the Welsh tinplate market is steady with prices from 20*s.* 6*d.* to 22*s.* 3*d.* f.o.b.

CONTRACTS.—The municipality of Copenhagen has placed a large order for water-tube boilers with the Vickers-Spearing Boiler Company, of Barrow-in-Furness. This is the second contract the municipality has placed with this company recently.

BRITISH CAST IRON RESEARCH ASSOCIATION.—The third annual general meeting of the British Cast Iron Research Association was held at the Institution of Mechanical Engineers, Storey's-gate, Westminster, on Wednesday last, when Mr. H. B. Weeks presided. The annual report of the association recorded continued progress in membership and in activity. Researches are in progress on erosion—and corrosion-resisting cast iron, moulding sands, automobile cylinders and pistons, graphitisation of iron, heat-resisting cast iron, the production of malleable cast iron, cupola practice, electrical and magnetic cast iron, pouring temperatures, properties of grey iron, test bar standardisation, facing sands, &c., abrasion resisting cast iron, pearlitic cast iron and aluminium in cast iron. Reports are being issued as this work proceeds and publication of other matters of interest to the members is also undertaken. Lord Weir, who has rendered valuable service to the association as its president, having completed the limiting period of office prescribed in the articles of association, was accorded the thanks of the association for the work he had done on its behalf and was elected an honorary member. In succession to him, Sir John Dewrance was unanimously elected president. As vice-presidents, Sir William Ellis, Messrs. George Pate, Summers Hunter, F. W. Firth, C. E. Lloyd and W. B. M. Jackson were elected to fill vacancies. By the unanimous vote of the members, Dr. Walter Rosenhain and Professor T. Turner were elected honorary members of the Association.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night at 6 p.m., at Storey's-gate, S.W.1. General Meeting. "First Report of the Marine Oil-Engine Trials Committee." Friday, November 28, at 7 p.m., Informal Meeting. "Centrifugal and Rotary Pumps." Introduced by Mr. G. L. Ponsford.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—To-night, at 6.30 p.m., at the Engineers' Club, Coventry-street, W.1, "Graphical Methods of Aircraft Structural Design," by Dr. Thurston.

THE INSTITUTION OF PRODUCTION ENGINEERS.—To-night at 7.30 p.m., at the Engineers' Club, Coventry-street, W.1., "Gear Cutting with Special Reference to the 'Sykes' Generating System," by Mr. O. H. Medcalfe.

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night at 7.30 p.m., at 39, Victoria-street, S.W.1. Lecturette, "Stainless Steel," by Mr. J. G. Hopcraft. Friday, November 28, at 6.30 p.m., Exhibition of latest Scientific Instruments and Appliances for the Use of Engineers.

THE INSTITUTE OF TRANSPORT.—Monday, November 24, at 5.30 p.m., at the Institution of Electrical Engineers, Victoria-embankment, W.C.2. Discussion of "Transport on the Highway," by Mr. A. E. Bassom.

THE ROYAL SOCIETY OF ARTS.—Monday, November 24, at 8 p.m., at John-street, Adelphi, W.C.2. Cantor Lecture.—"Modern Colour Problems" (Lecture 1), by Louis C. Martin, D.I.C., A.R.C.S., D.Sc. Wednesday, November 26, at 8 p.m. Ordinary Meeting. "Talking Motion Pictures" (with Practical Demonstrations), by C. F. Elwell, B.A.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, November 25, at 6.30 p.m., at 85-88, The Minories, Tower-hill, E.1. "The Rôle of Technical Training in Marine Engineering." by Mr. D. Laugharne Thornton.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Tuesday, November 25, at 7 p.m., at the Society of Motor Manufacturers and Traders, Limited, 83, Pall Mall, S.W.1. Informal Meeting. Cleaning Devices for Motor Cars will be demonstrated and discussed.

THE INSTITUTION OF WELDING ENGINEERS.—Tuesday, November 25, at 8 p.m., at the Caxton Hall, Westminster, S.W.1., "Resistance Welding," by F. E. Saunders, M.I.E.E. "The Microstructure of Arc-Welded Steel," by H. H. Abram, M.Sc.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—Thursday, November 27, at 7 p.m., at the Engineers' Club, Coventry-street, W.1. "Automatic Train Control," by Mr. F. J. Hookham.

THE ROYAL METEOROLOGICAL SOCIETY.—Friday, November 28, at 5 p.m., at the Imperial College of Science and Technology, Imperial Institute-road, South Kensington, S.W.7. Joint Meeting with the Physical Society. Discussion on "Ionization in the Atmosphere; the Influence on the Propagation of Wireless Signals." (1) Opening Address by Dr. W. H. Eccles, F.R.S.; (2) "Atmospheric Ionization and Its Variations," by Dr. C. Chree, F.R.S.; (3) Experimental Observations of the Strength of Wireless Signals as Affected by the Path of the Signals, Time of Day and Season of Year," by Prof. E. V. Appleton, M.A., D.Sc.; (4) "Atmospherics," by Mr. R. A. Watson Watt, B.Sc.; (5) "The Electric Field of a Thunderstorm and Some of its Effects," by Professor C. T. R. Wilson, F.R.S.; (6) "The Evidence of Terrestrial Magnetism for the Existence of Ionized Layers in the Upper Atmosphere," by Professor S. Chapman, F.R.S.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, November 28, at 7.30 p.m., at the Literary and Philosophical Society, Newcastle-upon-Tyne. "The Prediction of Critical Speeds in Ship Resistance," by Mr. John Tutin, M.Sc.

THE HULL ASSOCIATION OF ENGINEERS.—Saturday, November 29, at 7.15 p.m., at the Municipal Technical College, Park-street, Hull. "Lifting Machinery for Docks," by Mr. W. J. Bowtell.

AEROPLANE PERFORMANCE ESTIMATES.—Minutes of Proceedings, No. 11, just issued by the Institution of Aeronautical Engineers, contains a report of a paper entitled "Aeroplane Performance Estimates," read before the Institution on February 8 last, by Mr. R. Chadwick. The publication is obtainable from the offices of the Institution, at 60, Chancery-lane, W. C.2., price 1*s.* 6*d.*

THE THERMAL EFFICIENCY OF GAS ENGINES.—An extra meeting of the Institution of Civil Engineers will take place on Thursday, December 11, at 6 p.m., which members of the Institution of Gas Engineers, and of other institutions interested, are invited to attend. A paper by Captain H. Riall Sankey, on "Standards of Comparison in connection with the Thermal Efficiency of Steam Engines," is to be submitted for discussion.

THE LATE MR. WILLIAM MCLEAN.—We regret to have to record the death of Mr. William McLean, chairman of Messrs. William McLean, Limited, of Stirling Chambers, Campo-lane, Sheffield, which occurred on the 13th instant. Mr. McLean, who was only 49 years of age, was for a number of years connected with Messrs. Cammell Laird and Co., Limited, of Sheffield, and founded the firm of Messrs. William McLean, Limited, iron and steel merchants, about 13 years ago, on leaving Messrs. Cammell Laird.

DROP STAMPS WITH MULTIPLE IMPRESSION DIES.

CONSTRUCTED BY MESSRS. BRETT'S PATENT LIFTER CO., LIMITED, ENGINEERS, COVENTRY.

(*For Description, see Page* 705.)

FIG. 3. SINGLE IMPRESSION DIE STAMPS WITH THE ORDINARY FORM OF GUIDES.

FIG. 4. MULTIPLE IMPRESSION DIE STAMPS WITH NEW FORM OF GUIDES.

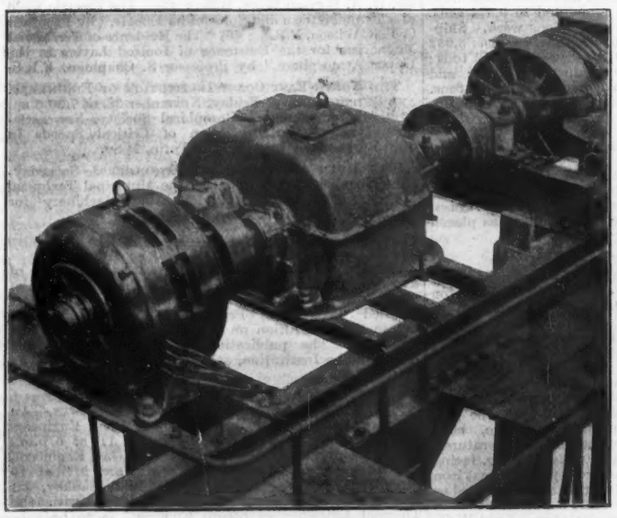


FIG. 5. THE DRIVING MOTOR AND ENCLOSED REDUCTION GEARING.

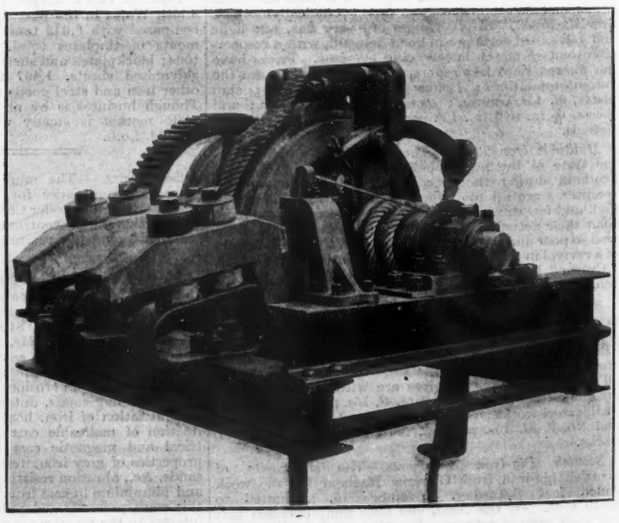


FIG. 6. THE LIFTER GEAR.

SILICA BRICKS.—During the burning of silica bricks the quartz changes into tridymite and crystobalite. It is sometimes maintained that, when this change has not been completed before the bricks are built-in, the bricks will afterwards not retain their strength. This view is not supported by the experiments made by Dr. E. Steinhoff at the experimental station of the Dortmund Union (Stahl und Eisen, Oct. 16). During the last stages of the transformation of insufficiently-burned bricks, Steinhoff found that the strength of the bricks fell off when taken at high temperature, under load; but there was a subsequent recovery probably owing to the gradual diminution in the grain size. The transformation is accompanied by a final expansion which amounted to 2·5 per cent. in the case of a very good brick, and to as much as 7·5 per cent. with an inferior brick. The control of the specific gravity is valuable in such test, but it does not make the determination of the expansion unnecessary. The Seger cone tests were found unreliable, and less characteristic than fusion tests of prismatic blocks. Bricks of the same kiln run are frequently not very uniform; at Dortmund a series of tests are, therefore, made as far as possible on the same brick.

1,000-KW. GEARED TURBINE AND CONTINUOUS-CURRENT DYNAMO.

CONSTRUCTED BY THE ENGLISH ELECTRIC COMPANY, LIMITED, ENGINEERS, RUGBY.

(*For Description, see Page* 698.)

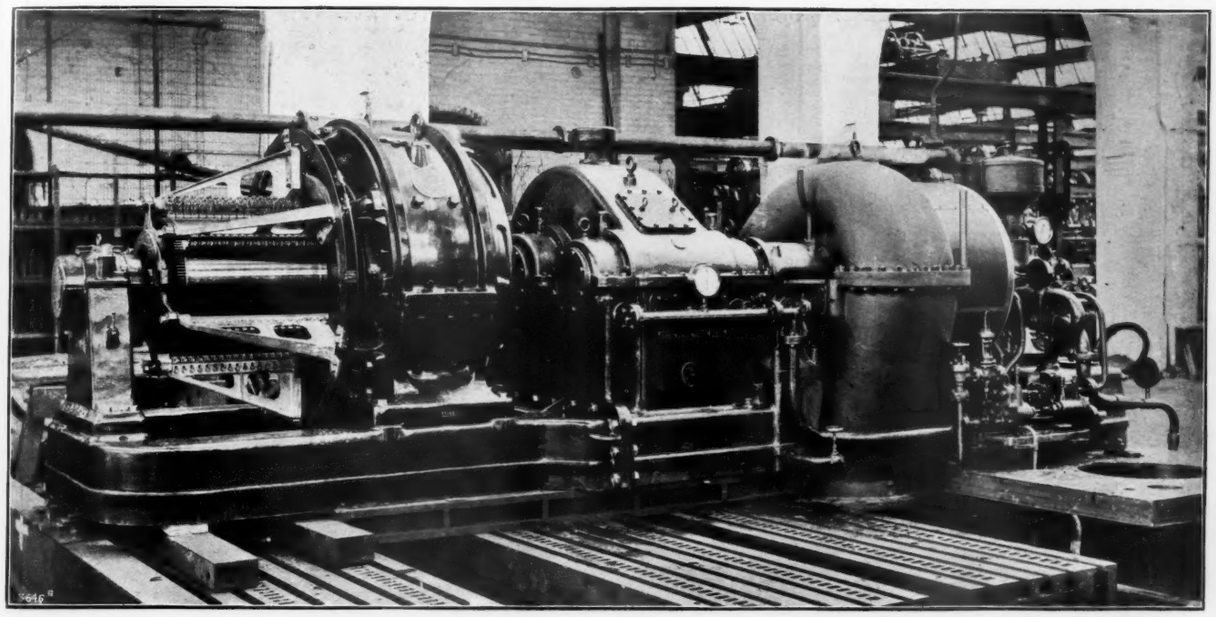


FIG. 3. 1,000-KW. GEARED TURBINE AND DYNAMO, FROM COMMUTATOR END.

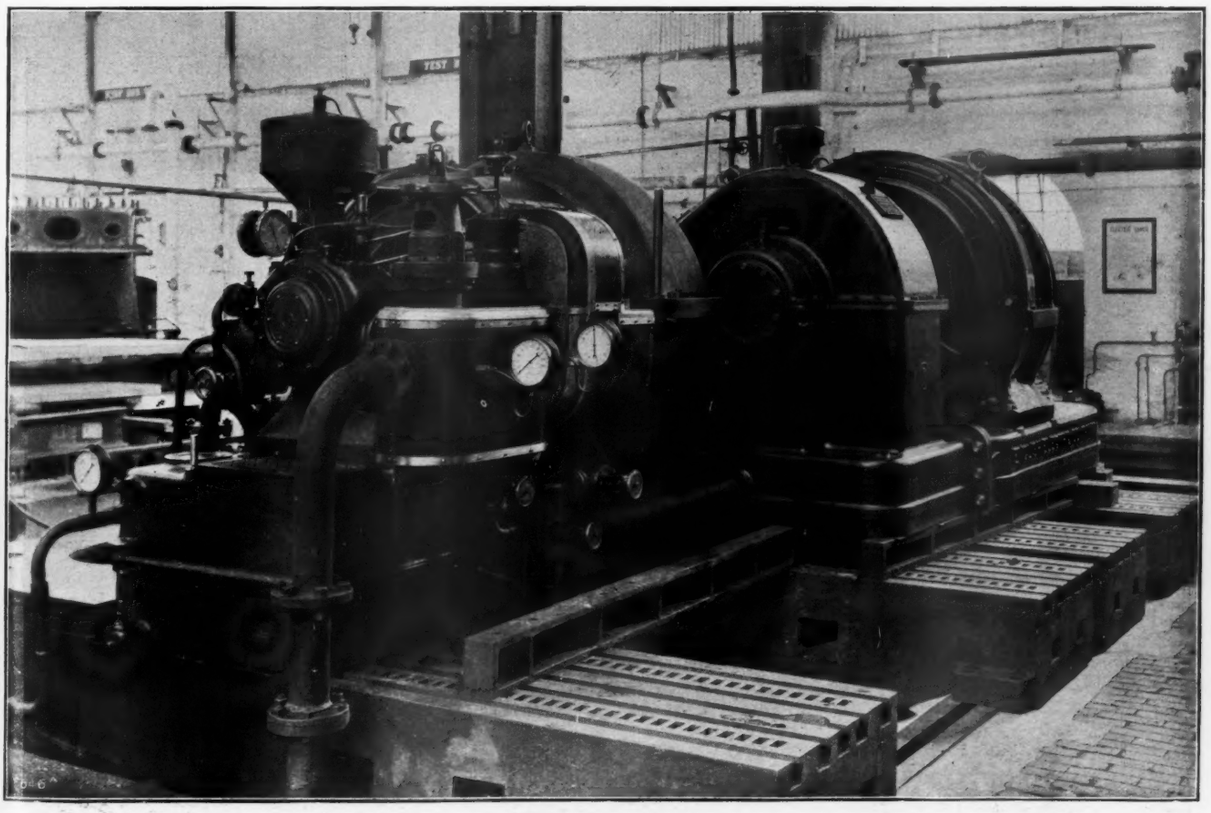


FIG. 4. 1,000-KW. GEARED TURBINE AND DYNAMO, FROM STEAM END.

(*To face page* 698.)

THE NEW TURBINE SHOP OF THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, LOUGHBOROUGH.

(*For Description, see Page* 699.)

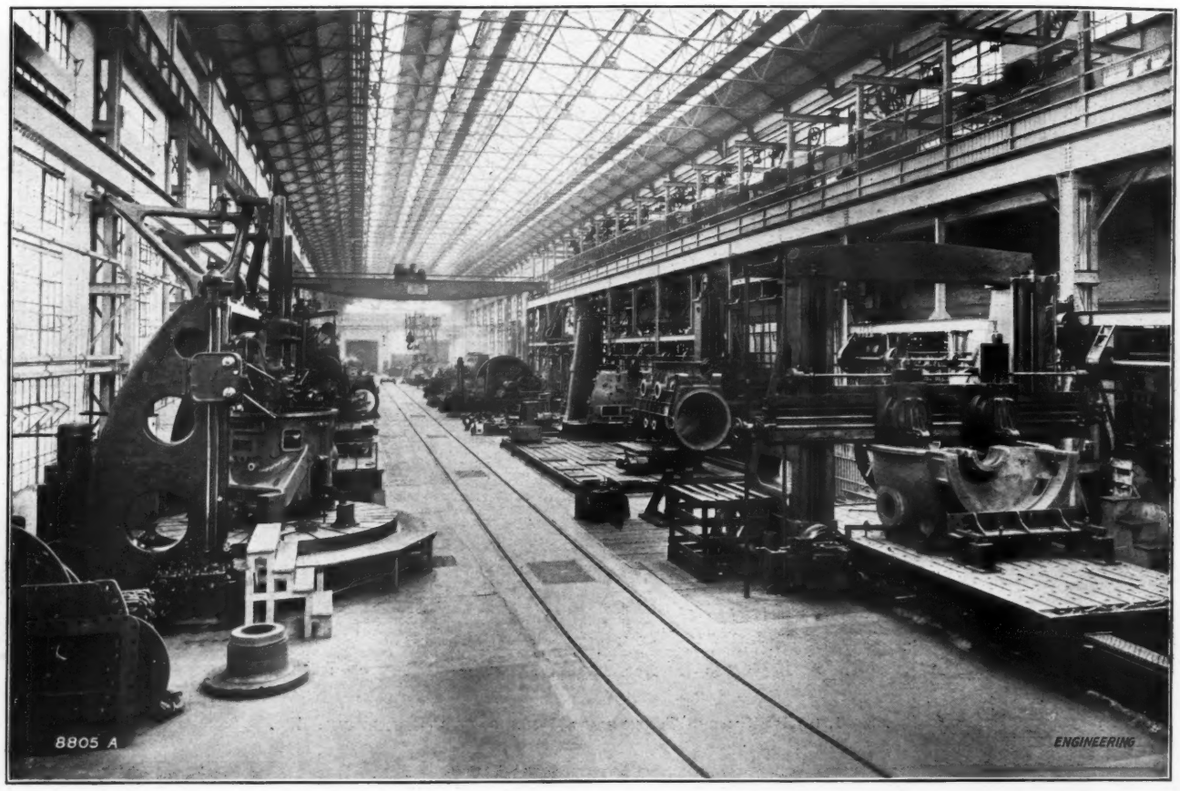


FIG. 1. VIEW OF SHOP FROM HEAVY MACHINE END.

FIG. 2. VIEW OF SHOP FROM ERECTING END.

(*To face page* 699.)

LARGE HORIZONTAL BORING MACHINE AT THE WORKS OF THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED.

CONSTRUCTED BY MESSRS. H. W. KEARNS, LIMITED, ENGINEERS, BROADHEATH, NEAR MANCHESTER.

(*For Description, see Page* 699.)

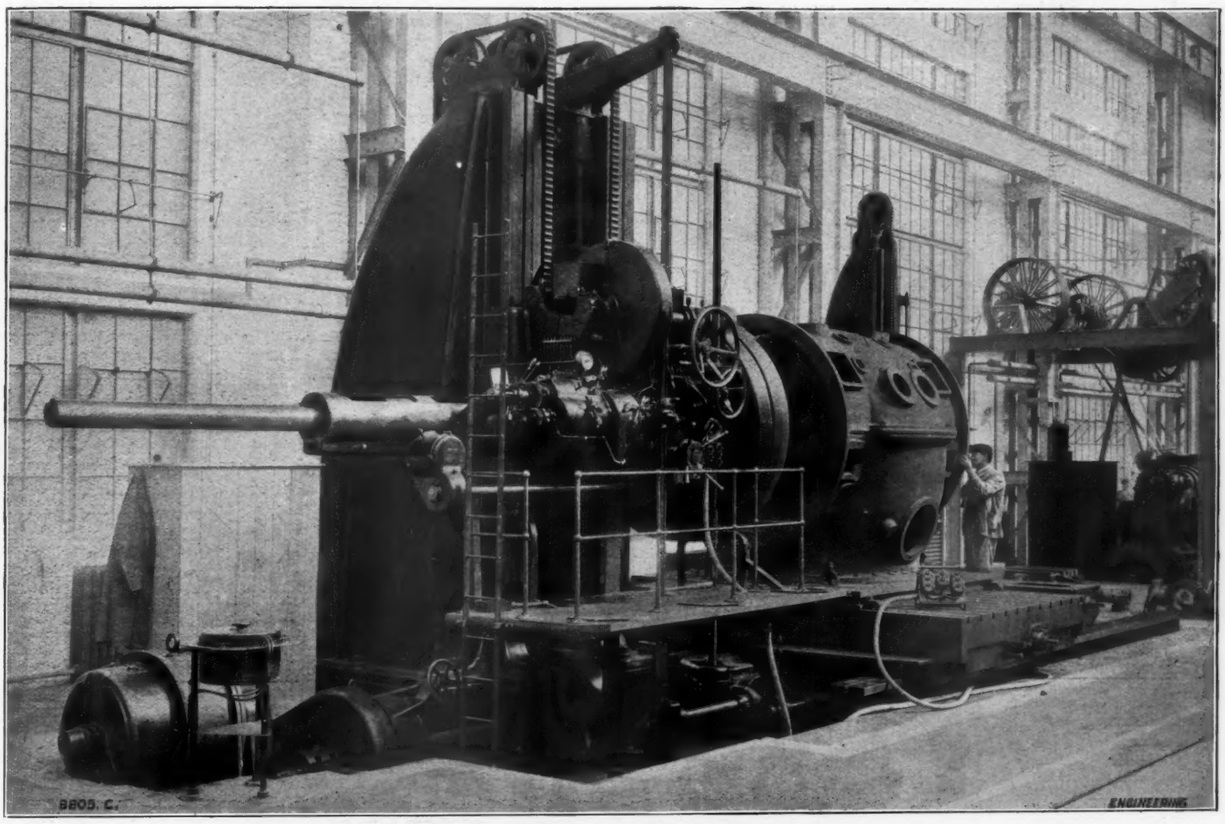


Fig. 4. Machine Boring a Turbine Casing.

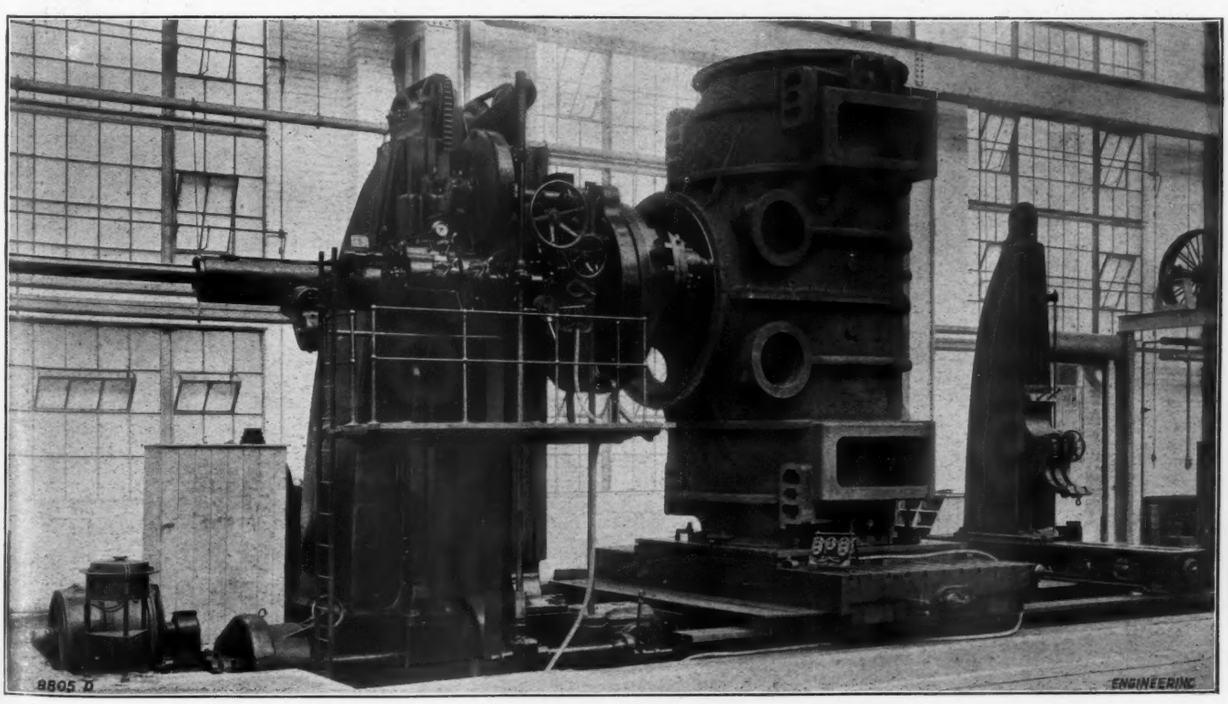


Fig. 5. Machine Facing-Up a Condenser Flange.

(*To face page* 700.)

THE TURBINE SHOPS OF THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, LOUGHBOROUGH.

(*For Description, see Page* 699.)

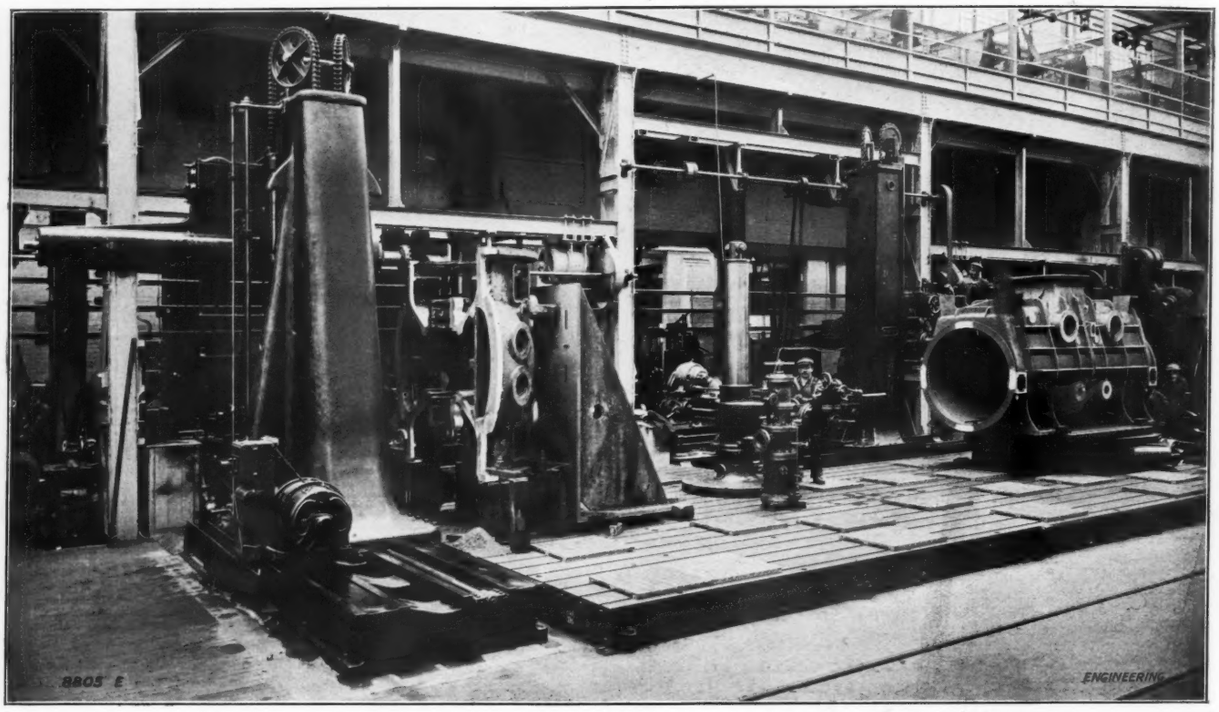


FIG. 6. WORK PLATE IN MACHINE SHOP.

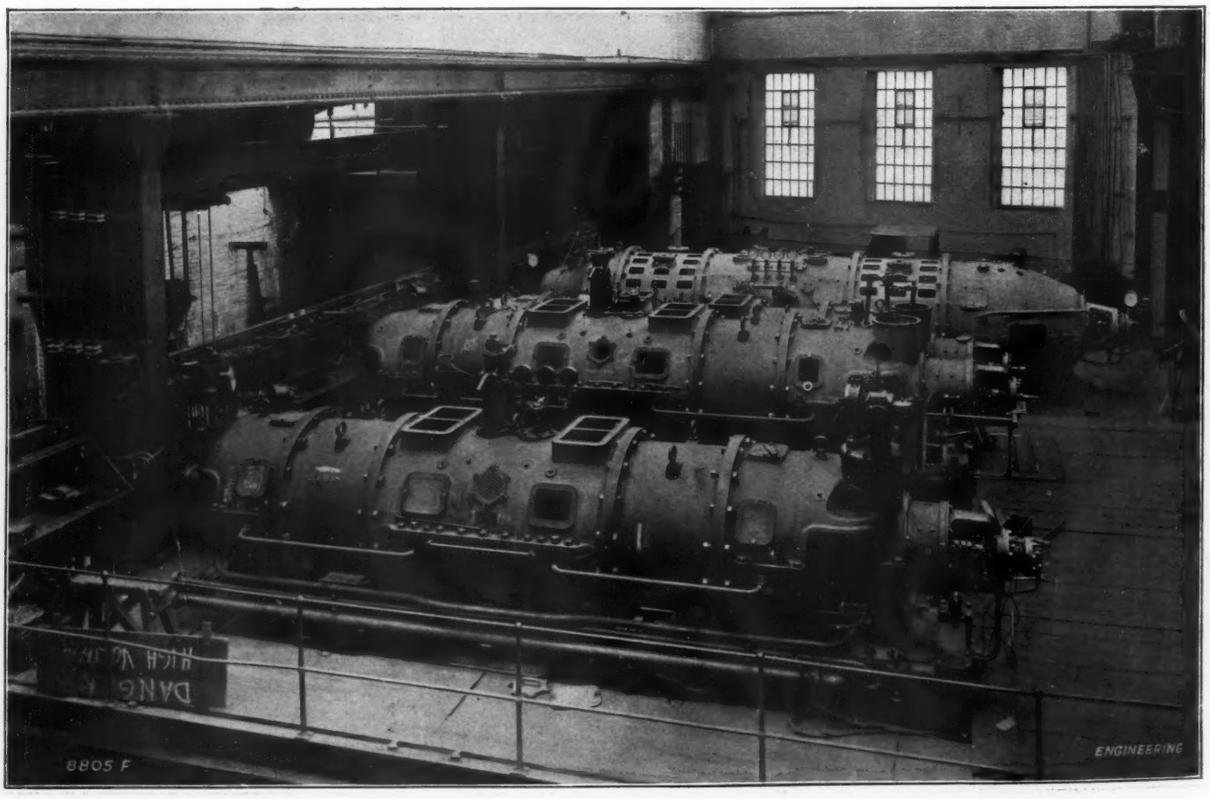


FIG. 7. BRUSH-LJUNGSTRÖM TURBINES ON TEST BED.

(*To face page* 701.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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TASMANIA: Gordon & Gotch Prop'ty, Ltd., Launceston: Hobart.

UNITED STATES: For Subscription, New York: W. H. Wiley, 440, Fourth Avenue. For Advertisements: J. S. Allan, 30, Church Street, New York.

CONTENTS.

	PAGE
Reparations and the British Engineering Industry	695
Gear-Tooth Testing.—I (*Illus.*)	696
Geared Turbines of the English Electric Company (*Illus.*)	698
The Manufacture of the Brush-Ljungström Turbine (*Illus.*)	699
Fractional Horse-Power Motors	700
Notes on New Books	700
Books Received	701
Crude-Oil Engine Shunting Locomotive (*Illus.*)	701
Letters to the Editor.—Dissociation in Gas Engines. "The Determination of Stresses by Optical Methods." Steam Turbine Efficiencies	704
Drop Stamps with Multiple Impression Dies (*Illus.*)	705
The Late Mr. James Smith Morrison	706
The Late Mr. James Stuart	706
The Late Dr. Bruno N. Nordberg	706
Notes from South Yorkshire	706
Notes from Cleveland and the Northern Counties	707
Notes from the North	707
Notes from the South-West	707
Notices of Meetings	707
The Risk of Accidents	709
The Flettner Rotor Ship	710
The Late Sir Maurice Fitzmaurice (*With Portrait*)	710
The Society of Naval Architects and Marine Engineers of America	713
Literature.—Sixty-Three Years of Engineering, Scientific and Social Work	714
Notes	715
Labour Notes	715
The "Sentinel-Roadless" Tractor (*Illus.*)	717
The Extent of Cavitation in U.S. Scouts and Destroyers (*Illus.*)	717
The Electric Road Vehicle	719
Petter Two-Stroke Oil Engines (*Illus.*)	720
Aeronautics in Naval Architecture	722
Self Unloading Bulk Cargo Vessels of the Great Lakes (*Illus.*)	723

Four One-Page Plates.—1,000-KW. GEARED TURBINE AND CONTINUOUS CURRENT DYNAMO. THE MANUFACTURE OF THE BRUSH LJUNGSTRÖM.

ENGINEERING.

FRIDAY, NOVEMBER 21, 1924.

THE RISK OF ACCIDENTS.

IT is one of the penalties of life to be liable to unforeseen mishaps. The statement that accidents will happen in spite of all that can be done to prevent them, has passed into a proverb, and an enormous amount of attention has been paid to the risks which are more or less inherent in every walk of life. Although it is, of course, quite impossible to predict that a given person will or will not meet with a particular kind of accident, it can be foretold with considerable accuracy, from statistics, how many of such accidents will occur among a large number of people in a given period, and upon the exactness of such knowledge the stability of every insurance company is founded. While, however, it may be sufficient for an insurance company, or a philosopher, to know that so many people in a million will certainly cut their fingers during the next twelve months, there is also a much more personal aspect of the matter. To the statistician the injured persons are mere units in a calculation, but to their families and their employers, and not least to themselves, they are real individuals whose disabilities are of serious moment. To know that, say, five men in every hundred will meet with an accident, trivial or otherwise, in the course of a year is merely a piece of information, but for an employer to realise that one out of every twenty men in his factory is almost sure to get hurt during the next twelve months, at once arouses anxiety.

Even supposing that all possible precautions for safety have been taken in a factory, it is still certain that accidents will occur, and it is equally certain that if any workmen, who, on account of their natural disposition, are peculiarly liable to cause or meet with accidents, could be transferred to some safer employment, the total number of accidents would be decreased. Before this can be done, however, it is necessary to discover whether it is a fact that any workmen are inherently more liable to accident than others, and if so, who they are. No employer would permit an epileptic or half-witted person to work among moving machinery, for their unfitness for such duties is obvious; but whether there are various degrees of liability to accident among apparently normal and able-bodied workpeople is another matter, and one much more difficult to decide. In the year 1919 the Industrial Fatigue Research Board, appointed jointly by the Department of Scientific and Industrial Research, and the Medical Research Committee, issued a report which claimed to show that the bulk of industrial accidents occurred to a limited number of individuals who had some personal susceptibility to accident. Accidents did not occur in proportion to the amount of work done by various employees, for no connection could be traced between the productiveness of a worker and the number of mishaps he met with. Furthermore, the state of health of any worker, in so far as this could be measured by the amount of time lost, did not appear to affect his risk of accident, nor did there seem to be any correlation between age and liability to accident. Accidents, in short, happened almost exclusively to a definite class of unlucky persons, predisposed to incur them.

These conclusions may be right or wrong, but they are, at any rate, of sufficient importance to make it worth while to examine with some care the evidence upon which they are based. They are deductions, arrived at by mathematical processes, from the records of a single national munitions factory during the Great War, and however correct the mathematical procedure may have been, the conclusions are clearly no more trustworthy than the data which went into the mathematical mill. These data were the entries in the ambulance-room book of the factory and referred, as we are told, almost entirely to trivial accidents, such as small cuts, slight burns, foreign bodies in the eye, &c., rarely involving either absence from work or recourse to a surgeon. No one conversant with workshop conditions, especially during war time, and knowing the tendency of some women to run to the ambulance room on any pretext, while others could only be induced by the exercise of authority, to leave their work and have minor injuries properly attended to, would take ambulance records half so seriously as the Medical Research Committee have done. The fact that some women had several accidents registered against their names, while others had none, has no significance whatever unless it can be proved that every woman was equally certain to go to the ambulance room for the treatment of a trivial injury.

Shortly after the publication of the report to which we have alluded, we pointed out that the theory that there existed a definite class of people peculiarly liable to meet with accidents, had not the least practical or scientific value in view of the worthlessness of the data on which the theory was based, and we should not have referred to the subject again had not the Industrial Fatigue Research Board just issued another pamphlet bearing upon the same matter. This new pamphlet is entitled "The Functions of Statistical Method in Scientific Investigation," and is to be obtained from H.M. Stationery Office at the price of 6*d.* net. We notice this report on page 701 of this issue. It is really only a reprint of a lecture delivered nearly eighteen months ago, by Mr. G. Udny Yule, who is not a member of the Board. Mr. Yule is, however, a very eminent statistical mathematician, and the purpose of his lecture was to point out the information which could be obtained from tables of statistics by subjecting the figures to appropriate mathematical treatment. To illustrate his argument he referred to the discovery of a special liability to accidents which appeared inherent in certain persons, and it is possibly on this account that the Industrial Fatigue Research Board decided to issue his lecture as a report.

This latest attempt to justify the theory of a special personal liability to accident is based on the

records of 116 women in the National Munitions Factory above referred to, over a period of four months. It was found that during the month of January, 1918, 61 of these women had no accident record, while the other 55 all visited the ambulance room on one or more occasions. During the previous three months the records showed that only 28 of the first group had met with accidents, whereas no less than 46 of the second group had one or more accidents registered against them. The number of women meeting with one, two and more accidents during the three months period is tabulated, one having as many as eight mishaps, and 14 women having more than an average of five accidents each. Such trivial data have been considered worthy of a mathematical investigation by the Research Board, and they have arrived at the result, which is indeed fairly obvious from a mere inspection of the figures, that the group of girls who met with a large number of accidents during one period also met with a large number during a subsequent period. This is taken to justify the theory that certain girls have a special predisposition to accidents, and that "trivial accidents are indicators of unsafe people whom the record of the ambulance room can be employed to discover."

Now it is definitely stated in the earlier report of the Research Board that the 116 women whose records were examined for the purpose of this analysis, were a "random sample" of the factory workers. Their occupations are not given, and it seems to be perfectly clear from the context that no regard was paid to the kind of work upon which the women were engaged. Hence the group who met with few or no accidents, may have been doing jobs in which the risk was exceedingly small, while the others were exposed to much greater chances of injury. To compare the accident records of floor-sweepers or time-checkers with those of machine-workers would be the height of ineptitude, and if, as seems likely, this kind of thing has been done, the whole of the conclusions fall to the ground. Furthermore, even supposing this point had occurred to the committee and, instead of taking a "random sample" of women, they had confined their comparison to women doing similar operations on similar machines, any deduction from the ambulance book records would have been hardly less worthless. The fact that such girls as went to the ambulance room during one month figured largely in the records for a subsequent month, might merely show that they were of the type who thought it wise to have every trifling cut properly attended to. On the other hand, it might be found that they were working machines with stiff chucks, awkward handles, or some other defects which caused bruised or scratched fingers, &c., from which the operators on other machines were more or less free. Again, the attitude of different supervisors towards trifling injuries would make a decided difference in the number of girls who went for treatment, so that when all things are considered, the chances that any useful conclusions could be drawn, even by the best of mathematicians, from the records of 116 women taken at random, are negligibly small.

It is quite certain that the Industrial Fatigue Research Board will never gain the confidence of practical men by investigations of the character we have described. The question of the liability of workers to accidents is not to be solved merely by an application of the mathematical theory of probability to the entries in an ambulance room book. It can only be intelligently discussed by men thoroughly conversant with workshop practice and fully cognisant of all material facts relating to the data which they are studying. The Board does not comprise a single engineer, and the confidence with which it has embarked upon an engineering enquiry is only equalled by the lack of confidence which its conclusions deserve. We would commend to the members the following quotation from Mr. Yule's lecture. "The statistician is dealing with most complex cases of multiple causation. He may show that the facts are in accordance with this hypothesis or that. But it is quite another thing to show that all other possible hypotheses are excluded, and that the facts do not admit of any interpretation other than the particular one he may have in mind." This is a wise saying, but unfortunately the people who need the warning most are just those who have not sufficient knowledge of the subject they are investigating to realise that the facts will bear more likely interpretations than the one they "have in mind."

Those who draw conclusions from statistics, the meaning of which they do not fully understand, are just the people who give point to the gibe "You can prove anything by statistics." It is more nearly true, as Mr. Yule has said, that statistics really prove nothing. Wisely interpreted they will show that certain deductions are possible or probable, but when misused, as they are so liable to be, statistical methods are, as we have shown, an extremely dangerous tool.

THE FLETTNER ROTOR SHIP.

During the past few weeks there have been frequent references in the daily Press to a new kind of sailing vessel in which propulsion is secured by the action of the wind on vertical rotating cylinders. Judging from the reproductions of photographs which have appeared, these towers are about 12 metres high by 2½ metres in diameter. It seems pretty evident from the illustrations in question that the principle involved is the same as forms the basis of the Lanchester-Prandtl theory of aeroplane lift and drag, and were a cylinder a stream line form for actual fluids, the propulsive force could be calculated accurately from the equations given in our issues of January 4 and January 11 last, (pp. 3 and 35). It was there shown that the surface of a rotating cylinder could be regarded as one of the stream lines of a Rankine free circular vortex.

The velocity produced by such a vortex at a distance of r centimetres from the centre is equal to $\frac{ta}{r}$, where t denotes the tangential velocity of the cylinder in cm. per second, and a the radius of the cylinder in centimetres. If we have in addition to this vortex a cross flow of air, the speed of the air will be augmented on one side of the cylinder and diminished on the other. But by Bernoulli's principle an increase of velocity implies a decrease of pressure and *vice versa*, so that a pressure difference is established on opposite sides of the cylinders, tending to make the latter move athwart the wind. Assuming the cylinder to be a stream line form, as it is for a perfect fluid, it was shown on page 3 of our issue of January 4 last, that the total force on the cylinder would be ρ V Γ dynes per centimetre of its height. Here ρ is the density of the air in grammes per cubic centimetre, V the wind velocity in centimetres per second, whilst Γ is the "circulation" due to the vortex.

As shown on page 35 of our issue of January 11, the value of Γ is equal to the angular velocity of the cylinder multiplied by twice the area of the cross section of the cylinder expressed in square centimetres. Of course, a cylinder is not a stream line form for actual fluids, but it is of some interest to calculate the possible thrust on the Flettner towers from the above expression. If we assume the towers to make one turn per second, the angular velocity will be 2π. Taking the cylinder as 250 cm. in diameter, its area will be 49,087 sq. cm., so that the corresponding circulation is given by $\Gamma = 2\pi \times 2 \times 49{,}087$. If we assume that the wind velocity is 500 cm. per second, and take ρ as $1{\cdot}293 \times 10^{-3}$ grammes per cubic centimetre, the value of the force on the tower, if it be 1,200 cm. high, is

$$1{\cdot}293 \times 10^{-3} \times 500 \times 2\pi \times 2 \times 49087 \times 1200 \text{ dynes} = 4{\cdot}786 \times 10^{8} \text{ dynes} = 1076 \text{ lb.}$$

As there are two towers the total force will, on the assumption made, be double this.

Since a cylinder is not a stream line form for real fluids, actually in the first place we may expect the propulsive effect to be diminished, and in the second that this force will not be perpendicular to the wind; because, owing to the breaking away of the stream lines, there will be a region of low pressure on the lee side of the towers. It appears from the foregoing that the rotor ship could not move into the eye of the wind, but with a head wind would have to tack like an ordinary sailing vessel. Over the latter it would appear to have the advantage of requiring fewer hands; but unless there be some arrangement for "reefing" the towers, it would seem less able to face a hurricane than a sailing ship under bare poles.

THE LATE SIR MAURICE FITZMAURICE.

A wide circle of engineers in London and abroad will learn with regret of the death, at the age of 63, of Sir Maurice Fitzmaurice, at his residence, 54, Onslow-square, S.W., on Monday last. Sir Maurice Fitzmaurice was responsible for many of the changes which have so transformed London in the past twenty years, while he was also connected with some similarly fine examples of British engineering work in other parts of the world.

The son of the late Dr. Robert Fitzmaurice, of Tralee, Co. Kerry, Maurice Fitzmaurice was born in 1861, and was educated at Trinity College, Dublin. Here he took his B.A. degree, and followed a three-years course at the University Engineering School, taking in 1883 the degree of B.Eng., with special honours. From 1883 to 1885 he was articled to the late Sir Benjamin Baker, K.C.B., under whom, in conjunction with Sir John Fowler, he was engaged between 1885 and 1888 on construction work on the Forth Bridge. The particular part of this great structure on which young Fitzmaurice was employed included the construction of the south main pier, requiring the sinking of four caissons under compressed air and the erection of 18,000 tons of steel work. He was some time subsequently, for two years in responsible charge of the construction of the approach railways on both sides of the Forth. This involved very heavy cuttings, viaduct and tunnel work. Between these two parts of his connection with the Forth Bridge, he was employed by Sir Benjamin Baker and Sir John Fowler on the construction of the Chignecto Ship Railway in Canada. This railway was designed to transport vessels of up to about 3,000 tons, on cradles, over the narrow neck of land connecting Nova Scotia with New Brunswick, between the Gulf of the St. Lawrence and the Bay of Fundy, the object being to cut out a very long detour, part of which was along a dangerous coast.

On the completion of his work in Canada, Fitzmaurice, still under Sir Benjamin Baker, was employed on plans and estimates for the replacement of cast-iron bridges by steel structures, on the London, Brighton and South Coast Railway. His next work of importance was in connection with the construction of the Blackwall Tunnel, for which, in 1892, he was appointed joint resident engineer, under Sir A. R. Binnie, then chief engineer to the London County Council. The other resident engineer on this work was Mr. David Hay, and the two, on the completion of the work, read a joint paper on the tunnel before the Institution of Civil Engineers in 1897. Although the experience on this undertaking did not solve all the problems of working under compressed air, it is generally admitted that the construction of the Blackwall Tunnel greatly enhanced our knowledge of the conditions to be observed for successful working under relatively high pressures. The tunnel was the largest undertaking of its kind at the time, and the work of construction was most successfully carried out.

The next undertaking with which Mr. Maurice Fitzmaurice was connected was of much greater magnitude and in many respects of far greater importance. In 1898 he was appointed Chief Engineer to the Egyptian Government on the construction of the Assuan Dam, designed by Sir William Willcocks. This work was finished at the end of 1901. The construction of this dam, and the size of the project made it one of the greatest engineering works of the time. Few single works have probably so transformed the face of the earth, and whatever ultimately becomes of our connection with the country of Egypt, the fact will go down to history that the British regime was at least responsible for successfully re-ordering the irrigation system of that land, and thus of restoring it to prosperity. The account of the construction of the dam was well told by Mr. Maurice Fitzmaurice in a paper he read before the Institution of Civil Engineers in 1903. As will be remembered, the decision was ultimately taken to raise the height of the dam

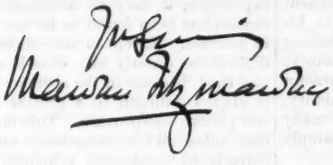
to a considerable extent, a proposal which aroused a good deal of controversy on engineering, and once again on, archæological grounds. The alteration, however, undoubtedly greatly increased the value of the work to the country below it. The alteration was completed in 1912.

In 1902, following the retirement of Sir Alexander Binnie, Mr. Maurice Fitzmaurice was appointed Engineer-in-Chief to the London County Council, and was thus identified with many of the notable changes which have been brought about in London. Although some of this work is evident to any superficial observer, a considerable amount of it is out of sight, and serves its purpose so well that it practically escapes notice. It is the engineer's lot often to work behind the scenes and, as Mr. Basil Mott remarked recently in his presidential address before the Institution of Civil Engineers, he often fails to get any reasonably fair credit for the services by which a large city is able to exist in comfort.

Mr. Maurice Fitzmaurice assumed the office of Chief Engineer to the London County Council at the beginning of a period of great activity in the Metropolis. It had been evident for some time that the whole system of dealing with the drainage of the area in question required revision. Very little had been done to improve matters since 1874, when the main system of sewers had been completed by Sir Joseph Bazalgette. When Mr. Fitzmaurice took up his duties a programme devised by Sir Alexander Binnie was waiting to be put in hand. The main lines of the scheme of extension were decided upon before Sir Alexander retired from office, but practically the whole of the detail work fell on Mr. Fitzmaurice, as well as the work entailed by supplementary extensions not covered by the original plans. This scheme was for the most part brought to a successful conclusion during Mr. Fitzmaurice's regime. The cost in all amounted to some 4,000,000*l.* and individual contracts were let up to a value of 481,000*l.* The length of additional sewers constructed in this extension amounted altogether to 87 miles, and included on the north side of the Thames, the Northern Outfall enlargement by two sewers, 9 ft. by 9 ft., laid for a distance of 10¾ miles; the Middle Level sewers No. 1 and No. 2, together 10 miles long; and the Low Level sewer No. 2, of 12⅝ miles. On the south side, the largest works were the Low Level sewer No. 2, 8¾ miles in length; High Level sewer No. 2, 10 miles long; and the Southern Outfall sewer, of 8 miles. In addition to these, a large amount of additional storm relief sewers was laid. The total discharge capacity of the system when Mr. Fitzmaurice came into office was 718 million gallons per 24 hours. This was enlarged by an additional outfall capacity of 814 million gallons, plus additional storm water pumping capacity of 639 million gallons. The total additional capacity was thus 1,453 million gallons, making a grand total of 2,171 million gallons for the new and old systems together. In spite of this large increase, additional works were in hand at the time that Mr. Fitzmaurice retired.

After the advent of tube railways in London the carrying out of this kind of work was much complicated. Most of the sewers were constructed by tunnelling, a large portion being made by means of shields and working under compressed air. With a view to avoiding disturbance of property, cast-iron segmental construction, lined with concrete and brickwork, was largely adopted.

Photo. by Bassano.



Another important undertaking associated with Mr. Fitzmaurice's term of office was the construction of the shallow subway under Kingsway from the Embankment to Holborn, by means of which the County Council tramways secured connection between the north and south sections of London. This subway was constructed in connection with the Kingsway-Aldwych improvement scheme which has given us in course of time one of the finest streets in London. The total cost of this improvement ran out at over six millions sterling, though subsequently large receipts from sales have offset this figure. The cost of the subway itself worked out for the Kingsway section at from 250,000*l.* to 285,000*l.* per mile, while at the Embankment end the cost was at the high rate of 410,000*l.* per mile. The cost of the subway was 385,041*l.* In view of the proposals afoot to construct overhead or underground relief crossover roads at congested points, it is interesting at the present time to remember that considerable difficulties were experienced in arranging for the northern end of this subway, in order to secure simultaneously satisfactory terminal location and workable grades. Mr. Fitzmaurice's remarks on this point, made at a meeting of the Institution of Civil Engineers in 1910 when Mr. G. W. Humphreys described this work, for which he acted as resident engineer, are very instructive.

The Rotherhithe Tunnel, opened in 1908, was another large work for which Mr. Fitzmaurice was responsible. The contract for this work was let in 1904. The tunnel exceeded all previous ones under the Thames in size, and the work was carried out very expeditiously and with practical immunity from accident. The actual under-river length was completed in nine months. The cost of this undertaking was about 2,000,000*l.* The new Vauxhall Bridge is also one of Mr. Fitzmaurice's works. The work on the new bridge to Mr. Fitzmaurice's design was actually commenced in 1904 and was completed in 1908. This design superseded an earlier proposal for a masonry structure which was dropped owing to difficulty in complying with the requirements of the Act of 1895 authorising the construction of the bridge. The new bridge is a steel one of five arches of a maximum of 149 ft. 7 in. span. The width is 80 ft. between parapets.

The construction of the Thames Embankment at the new London County Council Hall on the south side of the river was another notable addition to the long list of improvements for which Mr. Fitzmaurice was responsible, and in this connection he was honoured with a knighthood when the foundation stone of the County Hall was laid by the King in 1912. He had previously been awarded a C.M.G. for his work on the Assuan Dam, in which connection also he was decorated with the Order of the Medjidie of the second class. He retired in 1912 from the service of the County Council to take up consulting work, and became a partner of the firm now styled Coode, Fitzmaurice, Wilson and Mitchell, engineers for harbours to the Crown Agents for the Colonies, and consulting engineers for harbours, docks, &c., at Singapore, Colombo, Lagos, &c., and chief engineers for the national harbours at Dover and Peterhead.

During the war his activities were very numerous. For some time prior to the outbreak (1912) he had been chairman of the Advisory Committee of the Admiralty on naval works, and held that office till 1919. He was chairman of the War Office Committee on Civilian Labour on London Defences, and was also on the Hutted Camps

Committee of the War Office. He paid two visits to the British Front to advise upon drainage matters. He was also chairman of the Treasury Committee on Aerodrome Accounts, of the Nile Project Committee of the Foreign Office, and of the Canal Control Committee of the Board of Trade. Other offices which he held included membership of the Advisory Council on Scientific and Industrial Research, of the Advisory Council of the Science Museum; vice-chairmanship of the Engineering Standards Committee; and was a member of the International Technical Commission of the Suez Canal, and the Royal Commission on Fire Prevention. He was for many years an officer of the Engineer and Railway Staff Corps, of which he recently was appointed Colonel-Commandant.

Sir Maurice Fitzmaurice was a Fellow of the Royal Society, and the University of Birmingham conferred upon him the degree of LL.D. His connection with the Institution of Civil Engineers began as a student when he won a Millar Prize. He became an associate member in 1887, and a full member in 1893, presenting to the institution papers which won for him both the Telford and Watt gold medals. These were on two of the works mentioned above, viz., the Blackwall Tunnel and the Nile Reservoir at Assuan. He became a member of Council in 1905, a vice-president in 1915, and was president of the Institution for the session 1916–17, coming to this office somewhat earlier than would have been normally expected, by an unusual combination of circumstances. His presidential address was quite out of the common, and in normal times would probably have attracted more attention than it did when people's minds were concentrated on the war. His subject for this address was the occurrence of failures, due to lack of knowledge of the earth and of materials, and to failure of the individual.

Sir Maurice Fitzmaurice was associated in his connection with Messrs. Coode, Fitzmaurice, Wilson and Mitchell with many important works abroad, as, for instance, the Johore Causeway, officially opened a few months ago, and with the Prai wharves; also with the improvement of the port of Lagos, of which we gave an account in our columns recently, and with the construction of harbour works and wharves at Kilindini, Mombasa. About three years ago he visited Hong Kong, and as a result a report was submitted for harbour improvements, which, however, have not yet been finally decided upon. In conjunction with Mr. Basil Mott he was called in to report on the question of the new bridge over the Tyne, and also on the Liverpool–Birkenhead Tunnel scheme, while at the instance of the Ministry of Transport he recently reported on the question of the construction of a tunnel under the Thames near Gravesend. He was also associated with Mr. Mott in a recent report on the condition of Waterloo Bridge.

Sir Maurice was considered to be an excellent colleague and chief. He was very careful in his work and in arriving at conclusions, but having formed opinions he was prepared to back them to his utmost ability. This trait in his character acquired for him a reputation of great reliability, which his successful connection with so many works of the first rank proves to have been amply justified.

COMMERCIAL VEHICLE MAINTENANCE.

In recent years the transport of goods by road has attained very considerable proportions, and at the present time it is probable that the number of commercial vehicles in use, exclusive of those used for passenger transport, does not fall far short of 200,000. Published figures of the working cost per ton-mile are conflicting, but under the most favourable circumstances the figure does not fall below 2·5*d.*, while 8*d.* probably represents an approximate average value. The cost per ton-mile by rail has risen very appreciably in recent years, but even at the present time 2*d.* may be said to represent a fair average and it is, therefore, of interest to enquire why the more expensive form of transport is preferred by a large number of firms in delivering their products. There are certain obvious advantages in road deliveries, amongst which may be mentioned collection from, and delivery to, the inside of the works—a system which is only possible in the case of rail transport in the comparatively rare cases where a railway siding enters the factory; control of the time occupied in delivery in cases where the vehicles are owned by the firm whose goods are being handled, and the absence of the expensive packing rendered necessary by the rough handling to which goods are liable in rail transport. Probably of these the control of the time occupied in delivery is the most important, and it is significant in this connection that the most successful results are generally obtained in cases where the same firm both own and utilise the transport fleet.

On account of the complexity of the issues involved, it is a matter of considerable difficulty for a firm to arrive at a figure which represents their transport costs at all accurately, and there is no doubt that in many cases such costs are needlessly high. This applies more particularly to the smaller firms where the selection of the form of transport is in the hands of a minor official. Such an individual rarely has access to the necessary data on which to base a true comparison of the alternatives available, and he will generally make his selection on a basis of what is convenient rather than of economy. Were all the data to be placed at his disposal, he could hardly be expected to strike a true balance between the advantages that we have mentioned on the one hand, and such points as maintenance charges, vehicles returning empty, garage accommodation, and a host of similar points on the other.

The difficulty of arriving at anything like a true estimate is brought out in a paper read this week by Major E. G. Beaumont on "The Maintenance of Commercial Vehicle Fleets" before the Institution of Automobile Engineers. In this paper Major Beaumont deals more particularly with maintenance costs, and opens up the interesting question of the most satisfactory design of the vehicle for general transport work. In this connection he deals mainly with the petrol vehicle, and the suggestions that he puts forward merit the most careful consideration. The question of the relative suitability of petrol and steam vehicles is largely one of weight, and it may be said in general that if the rating is over 4 tons the steam vehicle has the advantage. A comparison between the two types becomes very intricate after the point where they begin to overlap, but the petrol vehicle has an undisputed field in ratings up to about 3 tons, and we imagine that it is vehicles of this type that Major Beaumont had in mind in dealing with design and construction. The paper is full of the most interesting suggestions, and it is only possible to discuss one or two of these in the space at our disposal.

A preference is expressed for flexible in contradistinction to rigid chassis, and as the author speaks with the authority given by a very wide experience, it may be assumed that the flexible chassis has been found to be the more satisfactory in practice. Except in outstanding cases, it is very difficult to classify any chassis as either rigid or non-rigid, because in the ordinary chassis the frame is always stiffened to a greater or less extent by the various components. This must always be the case unless all the components are mounted on the three-point suspension principle, and we are not aware of any vehicle in which this system has been systematically adopted. There is no point in design in which greater confusion of thought exists than that of the three-point suspension, the custom of mounting a component on three lugs, instead of four, being frequently assumed to constitute the system. We are doubtful whether such an arrangement possesses any real advantages so long as the practice is retained of bolting the lugs rigidly to the frame. The degree of support given to the frame in such a construction entirely depends on the area of the bearing surface of the lug, and complete freedom would only be given if true point contact was obtained, a condition which is, obviously, impracticable. Even if such a construction were possible the bolt itself would be liable to impose a measure of rigidity. So far as we are aware, it is only possible to obtain the desired degree of freedom by the introduction of ball joints at all suspension points, and this practice does not appear to have received any serious consideration at the hands of motor-vehicle designers. It would probably not be easy to carry out. With such an arrangement a rigid frame would become unnecessary, the only condition imposed being that the flexure due to road shocks should never become sufficiently great as to result in permanent distortion of the material. This condition is by no means easy of attainment, and even with the support given by the present system of bolting on the components, permanent distortion is not uncommon. It should be borne in mind in this connection that the stiffening effect of the components is purely local, and that the point of maximum stress, which is generally a short distance behind the driving seat, receives no support beyond that given by the body, the effect of which can be almost neglected.

It is by no means certain that the conventional form of frame represents anything better than the survival of an early type. It is almost invariably made up of two side members of channel section joined by a number of cross-pieces and by the different components, an arrangement giving great lateral rigidity but relative flexibility in the vertical direction. The side members almost invariably have solid webs, and the distribution of weight is thus entirely unscientific. A comparison with aeroplane practice is justifiable in that a good strength—to weight—ratio is desirable in both cases, and no one would seriously suggest that the necessary strength should be imparted to an aeroplane fuselage by the introduction of a solid channel girder down each side. Major Beaumont mentions that after a period of service all chassis show more or less evidence of distress in loose or fractured bearer arms or subframes and loose or stretched bolts and rivets, and it would appear that such a state of affairs is inevitable so long as the whole vehicle constitutes a very complex, redundant structure for which it is impossible to make even an approximate calculation of the stresses borne by the frame. The degree of support given by the components will depend entirely upon the tightness of the bolts securing the lugs, and if one or more of these work slack the stress distribution is entirely altered.

A further objection to the present system lies in the fact that the engine and gear-box are bolted rigidly to the frame, and therefore act as braces for the latter. As a result, they are subject to internal distortions which will tend adversely to affect such points as the alignment of the bearings. The correct form of construction would appear to be to give sufficient rigidity to the frame to enable it without external support to withstand the maximum stress to which it may be subject without permanent distortion, and to mount the units in such a way as to allow complete freedom of movement in any direction. If this practice proved feasible it would constitute a strong argument in favour of unit construction of engine and gear-box, as in this case only three supports would be required instead of the six involved if the units are separated. Lack of accessibility is frequently urged against this form of construction and is a very difficult matter to deal with, as it largely depends upon the facilities for handling the various parts available in the repair shop. In general, the owner of only one or two vehicles is obliged to entrust his repair work to a local garage, where it is possible that the process of merely lifting the engine out of the frame will constitute quite a formidable job on account of inadequate lifting tackle. In such cases the mechanic is apt to define accessibility in terms of the practicability of stripping down almost any unit without removing it from the chassis.

On the other hand, if the vehicle forms one of a large fleet which are dealt with in a repair shop forming a unit in the transport scheme as a whole, the mechanic will probably prefer to remove the component complete from the vehicle and carry out any necessary repairs with freedom from the inconvenience caused by the proximity of adjacent parts. In such a repair shop the ease with which the component can be removed from the vehicle constitutes its relative accessibility, and it is making a heavy demand on the ingenuity of the designer if he is to satisfy the demands of both types of repairer. It may be said that, in general, insufficient attention is given to the question of the work involved in removing a complete unit from the

chassis, and it is frequently necessary to remove quite a considerable amount of superstructure before this can be done. Cases are not uncommon where it is necessary to remove the body before lifting the engine out of the frame. A minor point in this connection is that it is usually necessary to work the rubber connections along their respective pipes before removing either the radiator or the cylinder block, and a very appreciable saving of time would result if an ordinary flanged joint were provided in addition to the rubber connecting pipe.

Another interesting point raised by Major Beaumont is the difficulty of obtaining fitters possessing sufficient skill satisfactorily to handle repair work. In the case of a large fleet maintenance depot this is merely a question of the time required to give workmen a suitable training, but, as we have already mentioned, a large number of vehicles are normally repaired in small garages. In such cases the fitter is called upon to carry out repairs to all types of vehicles, and an exceptionally wide experience and high degree of skill are required if the work is to be performed satisfactorily. It is notorious at the present time that conditions in the repair trade are extremely unsatisfactory, and an endeavour is being made by a prominent trade society to put matters on a better footing in this respect. Except in the case of large fleets, the owners of motor vehicles cannot employ a skilled engineer to represent their interests, and their own lack of engineering knowledge frequently results in dissatisfaction on both sides when they entrust their vehicles to the repairer. They frequently grumble at charges which appear to them to be excessive when the real condition of affairs is that the charge made is too low to enable the proprietor of the garage to employ a competent staff. We believe that mutual benefit would result if it became customary to employ a consultant in such cases, and that if this became the usual practice a considerable stimulus would be given to garage proprietors who are anxious to turn out a good job. The dearth of skilled garage mechanics constitutes a very real difficulty in the trade, and we do not believe that it will be overcome until the work of the semi-skilled men who constitute the major part of present garage hands ceases to be tolerated. It is not sufficiently realised that repairs to motor vehicles constitute one of the most highly skilled jobs in the engineering trade, and that the wages for such work should be correspondingly high.

It has only been possible to touch upon one or two of the lines of thought suggested by Major Beaumont's most instructive paper, and if answers to the 16 questions which form the summary of his paper can be thoroughly thrashed out a very helpful lead will be given to designers.

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS OF AMERICA.

The thirty-second general meeting of the Society of Naval Architects and Marine Engineers was held in the Engineering Societies' Building in New York City on Thursday and Friday of last week, when a series of 12 papers, many of them of considerable importance, was discussed.

At the meeting on Thursday, November 13, the first paper submitted was one on "Aeronautics in Naval Architecture," prepared by Commander Jerome C. Hunsaker, of the United States Navy. In this, the author referred to the indebtedness of the aeronautical designer to the work of naval architects and engineers in the early days of the new form of transport. Since that time much experimental work had been done, and the results were available for use in other ways than those for which they were primarily conducted. Especially in regard to fluid motion, questions of balance and stability, was the work of the aircraft designer useful to the naval architect. A reprint, in abstract, of this paper is given on page 722 of this issue of ENGINEERING.

Hydraulic Sea-going Hopper Dredgers.

The next contribution was made by Captain W. D. Styer, of the Corps of Engineers of the United States Army. In this paper, which had the title "Hydraulic Sea-going Hopper Dredgers," the equipment used in maintaining the channels at American seaports was described. Without constant dredging the depths of water necessary for modern steamships could not be maintained at such places as New York, Philadelphia, Norfolk and other important ports, as well as at the mouth of the Mississippi. Rapid shoaling action took place, and unless the material was removed as rapidly as it was deposited, navigation would early be made impossible. The modern development of sea-going hopper dredgers dated from the improvement of the Gedney and Ambrose Channels in New York Harbour. Here the natural entrance depth was 23 ft., which for many years proved adequate. Early in the 'eighties it became evident that improvement was necessary. The first attempt at deepening was made in the Gedney Channel by loosening the bottom with marine ploughs and permitting the ebb tide to carry the loose material out to sea. Later the material was lifted by pumps before being carried out to sea. The change in costs of working due to the use of larger dredgers and more efficient plant may be judged from the actual figures. The contracts for deepening the Gedney Channel in 1884–85 were placed at prices of 35 cents to 59 cents per cub. yard, while the average actual cost was only 27 cents. In contrast with this the net cost of the Government work in opening up the Ambrose Channel 22 years later was only 5·65 cents per cub. yard.

The modern hydraulic sea going hopper dredgers were steel twin-screw vessels, with moulded hulls, which resembled in outward appearance an ordinary commercial ship. In them, the dredging equipment comprised a powerful centrifugal pump, and a drag or suction head mounted on a drag hoist. Hoppers or bins with overflow troughs and dumping mechanism completed the equipment. When the dredger reached the bar to be worked on, the pump was started. The drags were then lowered to the bottom and the ship travelled over the bar at as low a speed as was consistent with maintaining steerage way. The weight and motion of the drag served to loosen the material and the effect was increased by the suction action, while it was assisted when the bottom was clayey or unduly hard by ploughs or scrapers attached to the drag, or by the use of water jets. The loose material was drawn up by the pumps from which it was discharged through pipes into bins. A furrow was made by each drag in the process every journey. These were nearly the width of the drag, from 5 ft. to 20 ft., and varied in depth from less than 1 in. to about 6 in. A drag tender, stationed in line with each suction pipe, controlled the drag by raising or lowering it to maintain the required pressure for efficient dredging. When the bins were full, the drags were raised out of the water and the ship proceeded out to sea, where the gates in the bottom of the hoppers were opened and the material discharged. This type of dredger had the advantage of being capable of use in comparatively rough weather, and could operate in channels with no more interference to shipping than was caused by any other vessel of similar size. The equipment used by the Army Engineering Department in this work consists of three types: the side drag dredger, with two drags, one on each side; the centre well dredger, with a small drag projecting through a well located about midships and along the centre line of the ship; and the stern well type.

The four sea-going dredgers constructed for the United States Engineer Department in 1922–24 were the first of the type employing the Diesel-electric drive. It was claimed that this system of transmission was suited to the slow speeds necessary in the work, by making manœuvring possible by means of the screws in addition to the rudder control. The method was suitable for deck control, which was advisable when work had to be done in congested harbours. Control on the Ward-Leonard system was arranged from the pilot house and the after engine room, and was interlocked so that changes could only be made from one station at a time. All the auxiliary machinery on these vessels was electrically operated. Three 1,000 brake horse-power Diesel engines, directly coupled to direct-current generators of 700 kw. capacity, giving a supply at 500 volts, constituted the power units, while two direct-coupled generators of 225 brake horse-power were installed for auxiliary purposes. These engines were grouped in two engine rooms, one fore and one aft of the hoppers. The dredge pump was of the volute centrifugal, single-suction type, with 26-in. suction and discharge. The dredging ladder was of the latticed, box-girder type, with diaphragms at intervals to stiffen the ladder and support the 26-in. suction pipe. Experiments were being made with a buoyancy tank in association with the ladder to relieve the pressure of the drag on the bottom of the channel when working in soft material, and thus prevent it burying itself to an unnecessary depth.

The third paper, relating to the "Self-Unloading Bulk Cargo Vessels of the Great Lakes," was the work of Mr. Henry Penton and Professor Herbert C. Sadler, and is reprinted in abstract on page 723.

Tank Experiments.

Three papers dealing with model experiments in tanks were then presented. In the first of these an attempt was made to show the relationship between the results of propeller tests conducted with models of different forms and dimensions. It was presented by Rear-Admiral D. W. Taylor, late of the United States Navy. To this contribution he gave the title "Comparison of Model Propeller Experiments in Three Nations," and in it he dealt with some of the work of Dr. R. E. Froude in Great Britain, of Dr. W. F. Durand and himself in the United States of America, and of Dr. Karl Schaffran in Germany. For the comparison the author used the system of basic variables, which naval architects will remember he enunciated in a paper last year. Although the propellers used in the tests showed considerable variations in size, when the results obtained with them were associated on Rear-Admiral Taylor's system, it was seen that it made very little difference, as regards propeller sizes, whether designs were based on the work of any of the four investigators. For three-bladed propellers the diameters obtained from Froude's, Taylor's and Schaffran's work would seldom differ by as much as 2 per cent., and the estimated propeller efficiencies showed very little variation. For four-bladed work the agreement between Durand, Schaffran and Froude was not so good, but for practical cases the differences between the highest and lowest results would only be 3 per cent. and the efficiency differences were not important. The close agreement of the results appeared quite remarkable.

Captain Ernest F. Eggert, of the United States Navy, then dealt with "The Extent of Cavitation in U.S. Scouts and Destroyers." This paper is reprinted on page 717 of this issue of ENGINEERING. "The Wake and Thurst Deduction of Self-Propelled Single-Screw Models" was then considered by Professor E. M. Bragg, who took as the object of his paper the determination of the extent that the wake and thrust of towed models could be used to predict those of self-propelled models.

Refrigeration in Ships.

The proceedings were opened on Friday, November 14, by Mr. Llewellyn Williams reading his paper on "The Design and Construction of Refrigerated Ships." In this contribution the author discussed the features which it was thought desirable to incorporate in a vessel intended to carry perishable cargoes. The economic speed for a refrigerated carrier was higher than that of a non-refrigerated vessel because the capital expenditure would probably amount to an additional 40 per cent. This higher cost necessitated a higher sea speed with a rapid turn-round in port to produce an equal earning capacity, unless extra compensation was made up by higher freight rates. In a fruit carrier the air-circulation system of cooling was generally carried out by means of air ducts running fore and aft along the sides of the vessel and connected to a battery of air-cooling pipes with blowers at the bulkheads. To keep down the air resistance it was important that the insulation surface was broken as little as was possible, and therefore deep beams, web frames, or extra deep brackets should be avoided where possible in 'tween decks. Decks laid flat instead of cambered were an advantage, and lines permitting straight shell plating were of advantage in dealing with insulation and stowage. Deck heights of 7 ft. below the beams were sufficient for uninsulated decks and

7 ft. 3 in. for insulated decks, while hatchways of 14 ft. by 12 ft. were large enough to handle a fruit cargo. The cargo should be raised off the deck by dunnage battens or gratings giving at least 3 in. of air space, and 2-in. dunnage battens should be used on all flat vertical surfaces. In carrying chilled meat the entire cargo was suspended from the under-side of the decks, and no deck gratings were required. Suitable deck heights must be provided, as the shippers would only pay for the portion of the available space which was actually used by their cargo. Suitable heights were 6 ft. 6 in. below the meat rails in 'tween-deck spaces and 9 ft. 6 in. for holds, from the under-side of the meat rail to the insulated deck surface, and increasing in 3-ft. increments. Refrigeration was performed by the use of brine-pipe coils suspended from under the ceilings and on the sides and bulkheads of the refrigerator compartments. The piping was arranged on the interlaced system, and supplies of brine at three temperatures—cold, tepid, and warm—made possible the easy control of the temperature. Bulkheads and side coils were protected by wooden battens to prevent the meat coming into actual contact with the cold piping and surfaces.

Mr. C. J. Jefferson showed how the American Shipping Board endeavoured to obtain economical working in their ships by the presentation of a paper entitled "Application of Fuel Conservation and Engineering Performance Standards to Shipping Board Vessels." For the purpose in view, forms were prepared for the presentation of reports on the state of the equipment, its use and consumption during the voyage. For the vessel a nominal efficiency figure was obtained for sea service and for port performance. It was claimed by the author that the method had been productive of considerable gains in economy and the efficiency figures at various periods were compared.

Scrapping Warships.

Commander H. E. Rossell, of the United States Navy, in a paper on "Scrapping Warships," described the methods adopted by the Navy and the American private shipyards. When dismantling, under the Washington Treaty, was started it was found that little information was available on the best methods of performing the work. Difficulties had been encountered in earlier work by the private concerns, and they showed little enthusiasm in making offers for the ships. The Navy Yard at Philadelphia therefore undertook a part of the work, comprising the cutting up of two partially completed battle cruisers, which were on the building ways, and five battleships, which were afloat, as well as rendering five battleships unsuitable for warlike purposes. The New York Navy Yard also undertook some similar work, and it was on the experiences gained, mainly in these two yards, that the subject matter of the paper was based. It was not generally appreciated, the author said, that in scrapping work the cost of oxygen and acetylene was quite as much as the cost of labour on the work. In Philadelphia, where a 350-ton crane, normally used for fitting out, was available, the first operation was the removal in one piece of the upper part of the bow. This rendered access easy and facilitated working and ventilation in the following stages. The large crane was also of service in removing 8-in. turrets, 12-in. guns and large parts of the structure of the ship. A large space was available for breaking up large sections into suitable sizes for transport near the big crane, and there were railway facilities alongside. The method in use, removal in large sections followed by further subdivision, proved much less expensive than competing the breaking-up on the ship, due to the great advantage of adequate provision of ventilation. The method of scrapping was such that it was inevitable that damage was done to every part of the equipment before it was removed. In addition to this the material was of special design, and usually not suitable for commercial purposes, and thus disappointment at the amount of usable material obtained was almost universal.

Motor Ships.

Some information on the operating costs of a motor ship was provided by Mr. Arthur B. Homer in a paper on "Trials and Operation of the Motor Ship Cubore." The vessel in question had a length of 468 ft. and a moulded breadth of 57 ft. It was propelled at a speed of 10 knots by a six-cylinder Bethlehem engine of the two-stroke single-acting air-injection type, which gave 2,400 shaft horse-power. Since being put into service in February, 1924, after many replacements on the original experimental engine had been made as the result of accumulated experience, the vessel ran 37,450 nautical miles in the following six months. Only 10·7 per cent. of the time of the voyages was spent in port. The same owners, the Ore Steamship Corporation, have a number of steamships of about the same size and working under similar conditions. Comparison was therefore possible of the fuel consumptions, and gave the following figures: tons of oil per day for a steam reciprocating-engined ship, 34·3; for a turbine-driven ship, 32·7; and for the Diesel-engined vessel, 12·0.

Mr. J. C. Shaw described what was done on the conversion of a steamer to motor propulsion, in a paper on "Problems in Connection with Conversion of the Hog Island Steamer Seekonk to a Motorship." The conversion in question was carried out by the Cramp Company. The vessel was 401 ft. length and of 54 ft. moulded breadth. Originally this vessel had a double-reduction geared drive to the propeller from a 2,500-h.p. turbine, supplied with steam from water-tube boilers. In place of this plant, a six-cylinder, four-stroke, single-acting Diesel engine of 2,300 indicated horse-power was installed. Electric auxiliaries were at the same time provided. The fuel consumption per day at sea under the new conditions for the main and auxiliary engines was given as varying from 7·7 tons in the winter to 7·3 tons in the summer. There was no exact information available on the fuel used prior to the conversion.

The use of the electric drive for ships has many advocates in America, and a paper on this subject as relating to a tug was contributed by Mr. Frank L. Du Bosque. The tug in question was one of the many that are used in New York Harbour in towing freight-laden boats from shore to shore over the waterway. An early Diesel engine direct drive installed in a tug of this type proved unsatisfactory, because it did not permit of the rapid acceleration and retardation of the boat. It was thought that the manœuvring capabilities obtainable with the electric drive would make possible the use of the economical Diesel engine in an exceptional service. Observation had shown that in an 8 hours' watch, engine control signals averaged one every 51 seconds. If control were possible from the bridge house greater flexibility in working could be, it was thought, obtained, and for this reason the electric drive was installed. Power was obtained from two Winton Diesel engines of the four-cycle type, each being connected to shunt wound generators of 235 kw., which delivered direct current electricity at 250 volts. These machines were connected in series to drive a 500-volt motor of 575 h.p. Control was effected on the Ward-Leonard system of variable generated voltage, so that any speed up to the maximum might be instantly obtained by the movement of a small control lever. The vessel was recently put into commission and the results so far obtained, it was suggested, had justified the use of the electric method of transmission. Comparison with a steam-operated tug showed that the weight of the machinery had been reduced from 177 tons to 165 tons as a result of the installation of the Diesel-electric system.

LITERATURE.

Sixty-Three Years of Engineering, Scientific and Social Work. By Sir Francis Fox, M.Inst.C.E. London: John Murray. [Price 18*s.* net.]

Biographies too frequently tell us what a man has accomplished rather than what he is; they exhibit his achievements rather than his character. Sir Francis Fox, however, in this chatty book, by combining the history of his social work with his engineering experiences, has revealed much of his innermost thoughts and ambitions. He has not devoted himself selfishly to his science, but has sought the improvement of those about him, and many may think the story of his efforts to promote the interests of others quite as edifying as the description of his mechanical triumphs. It is not given to many who, absorbed in their work, are actively engaged in onerous and hazardous enterprises to devote their leisure to the task of rescuing the fallen and encouraging the spiritless and destitute; but we imagine Sir Francis counts his endeavours in this direction not less worthy and encouraging than his better-known engineering achievements. These episodes are told with a rare simplicity that commands attention. The story of the man who attempted a burglary on Sir Francis' own premises, and in whom he implanted a sense of self-respect and probity, which lasted until he perished finally in the Great War, has in it touches of pathos that Sterne might have envied.

In these columns, however, Sir Francis appeals to us as an engineer, and a successful engineer. Born into a family that had played a worthy part in the earlier railway development in this country, his inventive and mechanical skill was naturally directed to railway construction; and the earliest independent work described here relates to the formation of the tunnel under the Mersey, in 1880, to connect Liverpool with Birkenhead, a scheme which, though satisfactory from an engineering point of view, has not proved an advantage to the original shareholders. It does not come within the compass of the book to enter into technical details, but small incidents in connection with great and pioneer undertakings are worth preserving, and the relation of these at first hand adds greatly to the interest.

From Liverpool we are taken to London, and are introduced to the methods of tunnelling that the Greathead shield makes possible, and which is responsible mainly for the construction of London's many tubes. It is a device particularly suitable for working through the London blue clay, but other strata may be penetrated, though with greater difficulty. But whether through blue clay or Woolwich beds, the line of work is never allowed to swerve to the right or left, but goes with unerring accuracy according to plan. We think the author has hardly done justice to those who are responsible for the accuracy of the preliminary trigonometrical survey. The figures are there, but the untechnical public for whom he is writing will hardly appreciate their full significance without greater emphasis is attached to them. In the case of the track from the Hampstead Heath Station to that at Belsize Park, a distance of 4,000 ft., the parties working from the north and south ends met so exactly that the opposing shields touched edge to edge, and were left in position to form a portion of the iron lining of the tunnel. The error in direction, or the deviation from an absolute straight line, is stated to have been a quarter of an inch, or almost exactly a second of arc, an angle less than any ordinary theodolite would measure. Later, we meet with a description of the Simplon Tunnel from Brigue to Iselle, a distance of 12¼ miles. Here the error of direction was 3⅔ in. This discrepancy is rather less than that met with on the Hampstead Heath line, and considering the greater length, is an even more remarkable piece of work. We are the more grateful for the latter figures, for we have always understood that owing to the unfortunate accident that marred the successful encounter of the opposing workmen, the alignment was never accurately determined.

In South Africa we are invited to contemplate another class of work. Tunnelling gives way to bridge making, and the Victoria Falls on the Zambesi are effectually spanned. Here the difficulties are of a different order, but demand organisation and supervision of the highest class. The problem of obtaining and distributing supplies in an unsettled country; the ravages of rinderpest among cattle and horses threatening the existence of both British and natives; forest fires that carry destruction to finished work; with many other disasters, all present problems to the management of a great undertaking that are hardly considered when we read of successful engineering operations, but it is precisely the side issues and the part they play in complicating the plans of those responsible, to which the author directs our attention. Canada was the scene of other interesting work in railway construction, and, indeed, the author's experience has

been wide and varied, qualifying him to criticise the work of others and to suggest the most judicious method for carrying out proposed operations.

A very informing section is that devoted to the restoration of cathedrals and ancient buildings, from which incidentally much may be learnt of the manner in which our ancestors selected sites, provided foundations, and constructed the ornaments that have charmed and inspired successive generations. The want of care, or indifference to building science, has wrought as much evil in these legacies of the past as the altered conditions of modern life and traffic. Of particular interest is the description of the means selected to give support to Winchester Cathedral, called for by the extent of the dilapidation and the presence of water. Apparently, this forms an early instance, if not the earliest, in which grouting on an extensive scale was successfully applied by machinery analogous to the cement gun, the object being to render the building practically monolithic. The beetle *Xestobium tesselatum*, that played such havoc in the roof of Westminster Hall, was encountered here, and where wood is a necessity, it is to be feared that this beetle will find opportunity for its ravages. Many other cathedrals at home and abroad were visited and repaired, and it is evident that the damage generally must be very severe before remedial measures are hopeless. A chapter is devoted to the state of St. Paul's Cathedral, whose condition is causing and will continue to cause, grave anxiety. The peculiar value of the chapter is that we have the conclusions submitted in a careful report made as far back as 1913, presenting the fruits of apparently the first rigorous examination since 1831, when the Corporation of London unwisely attempted to construct a deep sewer on the south side of the Cathedral.

The book concludes with many personal reminiscences of a busy and well-spent life, remarks on the altered conditions of workman and employer, of experiences that it may be unwise to neglect, and of other matters of the value of which individual readers will decide for themselves.

NOTES.

The Working Costs of Heavy-Oil Engines.

The Diesel Engine Users' Association have collected data as to the working costs of internal-combustion engines during the year 1923-24. These were discussed at a meeting of the Association, held on the 14th inst. The data of most interest are perhaps those showing the results obtained under conditions of a high-load factor and long-hour service. One of the returns provided by Mr. P. A. Spalding of Dundalk, covers a period of the past seven years, during which the price of the fuel has averaged 140/5*d.* per ton. Averaged over the whole period, the engine cost was 1·041*d.* per unit generated; the average annual plant load factor being about 20 per cent. The largest Diesel engine covered in the report was rated at 1,000 brake horse-power, and the smallest at 52 brake horse-power. The large engine mentioned has only been recently installed. The data collected refer to 34 stations, and the average number of hours worked during the twelvemonth was 2,060, which is 280 hours less than in the previous year. The annual plant load factor was 13·3 per cent., and the average engine-cost per unit generated was 0·899*d.*, as compared with 0·987*d.* in the preceding year. This reduction has been due to a decrease in the price of fuel, since owing to the lower annual plant factor, the average cost of repairs and maintenance has been slightly increased. The report states that even at present prices of liquid fuel the heavy oil engine furnishes not only an economical means for generating electric energy, but provides also a most economical stand-by capacity for taking peak loads. It is further stated that taking the average gross calorific value of the fuel used as 19,500 B.Th.U. per lb., the overall thermal efficiency of 37 stations employing 129 engines of various ratings up to 1,000 brake horse-power, was 23 per cent. The average fuel consumption of these was 0·748 lb. per unit generated, and the average load factor 57·7 per cent. The consumption of lubricating oil averaged 0·00195 gallons per unit generated, the lowest figure recorded being 0·00061 gallons; and it is stated that even this figure can be very materially reduced by the installation of effective oil separators. The figures collected indicate the annual cost of maintenance is of the order of 1*l.* per kilowatt of plant installed.

The Inner Structure of Metals.

Much work has been done of late to show that the resistance of any metal to stress is affected by the atomic structure, and that the actions which take place under loading may be explained by the change in the arrangement of the aggregate of crystals, of which the metal consists. Mr. W. E. W. Millington and Professor F. C. Thompson have recently presented a number of papers to the various metallurgical institutions, in which they have emphasised the value of the study of metal structure from this standpoint, and on Friday last they gave a further paper to the Manchester Association of Engineers, dealing with "The Practical Significance of the Inner Structure of Metals." In this contribution the authors first reviewed the inner structure of a ductile metal, representing it as being composed of an orderly arrangement of spheres in contact with each other. Although mild steel consists of two constituents of widely differing properties, ferrite and pearlite, it was shown that the mode of breakdown was unaffected by the presence of the pearlite, and that it only raised the stress value at which the elastic failure took place. The authors therefore were able to extend their work on pure iron to the case of mild steel. The theory of elastic failure put forward by Messrs. Millington and Thompson, in their paper, was that under complex stresses, simple ductile material would fail elastically when a plane existed in the stressed material on which the normal and tangential stresses were equal to each other, as well as equal to those operative in a simple tensile test at the elastic limit. Consideration of elastic failure from this standpoint, although there are still many factors in elastic failure which preclude the framing of, what may be termed, a law, proved very helpful in dealing with many problems. The points brought out in the paper were that in any complete solution of complex stress problems, as the material was built up of crystals, the stresses which caused elastic failure were different in different directions and that the effects of grain size, free surface actions, such as torsion and bending, and the effects of internal stress, due to work done on the material, must be taken into account.

Port Facilities.

In 1923 the Chamber of Shipping of the United Kingdom appointed an expert committee to visit and examine the facilities of the principal ports of Great Britain. In this the Association of British Chambers of Commerce, and the Federation of British Industries co-operated, and a committee was formed under the chairmanship of Sir Frederick W. Lewis. This committee elected two sub-committees, one to act as a general visiting body and the other to deal with the port facilities of London. Certain ports were dealt with by local committees assisted by members of the two main visiting committees. A preliminary report was issued some little while ago and notice was drawn to it in these columns. The committee's final report has appeared within the past few days. It runs to the length of 288 octavo pages mainly dealing in detail with the situation at different ports, and does not therefore lend itself to general discussion. The broad conclusions are on the whole very natural ones and what one would expect. It is satisfactory to note that in some instances the work has resulted in a definite crystallisation of the ideas of port authorities. There is no doubt that co-operation between shipping and port bodies should lead to fruitful results. The trouble with the port people is the fact that after heavy expenditure some turn of events may take shipping away from their waters. Generally speaking, traffic will go to the port offering the best facilities, within reasonable limits, but there have not been lacking in recent times changes in choice of terminal which must have been very discouraging to some port authorities. Much traffic, however, is relatively stable, and the provision of facilities then is a matter of economics and finance. Mechanical and engineering skill can provide almost anything at ports in these days; but it is a question to what extent such provision may be justified. If provision is made beyond the economic limit the cost of working the port goes up and dues have to be increased, with the probable result that shipping is driven away. Who is to bear this risk and burden? That these questions are not easy to answer was evident from the discussions, at the International Navigation Congress in London last year. The present report is the production of bodies interested in the shipping side. It is more than likely that the balance of argument would be against some of their proposals and it is necessary to have both sides clearly stated in such a case. It is, however, certain that we must have the best facilities, if, with our difficult conditions of strikes and short working days, we are to hold our own with Continental terminals, provided always the shipping can carry the necessary charges. This is the crux of the problem, and good will certainly result if in the endeavour to attain to ideal conditions parties are brought together so that fundamentals of this kind may be studied.

LABOUR NOTES.

The trouble which has arisen at the new super-power station at Barking is a much simpler affair than it is made to appear to be by the labour extremists, who have had most to say, publicly, about it. A Tyneside firm of contractors belonging to the Engineering and Allied Employers National Federation, sent its own men to Barking with electrical apparatus which it had constructed, paying them while they were at Barking the Tyne district rate plus the usual outworking allowances. The London Area of the Electrical Trades Union took exception to the procedure and insisted that not the Tyne rate plus outworking allowance, as agreed between the E.T.U. and the Engineering and Allied Employers National Federation, but the London rate, as agreed between the E.T.U. and the National Electrical Federated Association should rule. The firm adhered to its rights under the agreement between the E.T.U. and the Engineering and Allied Employers National Federation, and the strike which is in progress, took place. Attempts were made, but without much success, to involve other unions. Eventually, the shop stewards, representing the men employed at the light and power stations in the metropolitan area, took the matter up, and at a meeting in London on November 17, it was decided by a majority to ask the executives of the various unions concerned jointly to take up the matter with the Engineering and Allied Employers National Federation and, in the event of failure, to settle to take co-ordinated strike action at all the London power stations. A conference of representatives of the unions concerned will take place either late this week or early next week. The question is also to be discussed to-day, it is understood, by the Joint Industrial Council in the London area for the electricity supply industry.

The matter, as it stands at the time of writing, has at least, two very undesirable features. The dispute is between the Electrical Trades Union and the Engineering and Allied Employers Federation, and the issue much simpler than the average labour trouble. Yet the pressure which the E.T.U. is applying is on another body of employers altogether, and the issue is being obscured by threats—not all of them by irresponsible trade unionists—to "shut down London." The other undesirable feature is the regrettable tendency which some leaders of the men are showing publicly to discuss a difference which can only be mutually adjusted in conference with employers or decided by a tribunal. In other days, it was generally agreed that one could not fight and negotiate at the same time. Now, the idea apparently is that it is sound tactics to scare the community by extravagant claims and leave the pressure of public opinion to do the rest. Nor are the electrical workers the only believers in this new method. During the past few days, officials of other unions have followed it with distinctly disturbing effects, and there is no foretelling how far the evil may eventually go.

Representatives of the railway managers and the Associated Society of Locomotive Engineers and Firemen met in London on November 18 for the purpose of discussing the mileage system of payment for engine drivers and firemen. It was understood, when the strike of January last was settled, that negotiations on this subject would take place in due course. According to the settlement terms, the mileage to be reckoned as the equivalent of a day's work was to be increased at once from 120 to 130. In July there was to be a further

increase to 140 miles, and from the beginning of the first pay week in January, 1925, 150 miles were to "equal one day's pay unless, in the interval, it is agreed otherwise at a meeting to be convened for the purpose." After a discussion which lasted for an hour and a-half, the representatives of the managers intimated that they would give careful consideration to the representations, and either communicate their decision to the men's society or ask for another conference.

A recommendation by the Tramways Committee to place a contract for special track work with the United States Steel Products Company was rejected by Glasgow Corporation by 73 votes to 17. The American tender was 7,850*l.*, or 800*l.* less than the lowest British price. In moving that the contract should be given to the lowest British firm, Councillor Walker said that the American company refused to recognise the elementary right of workmen to combine to protect their interests. Fifty per cent. of our own steel-producing plants were idle, and the Americans were dumping their goods into this country at lower prices than they charged in their home market so as to prevent any revival of trade here.

The Ministry of Labour states that the number of unemployed persons on the registers of Employment Exchanges in Great Britain on November 10, 1924, was 1,218,400—930,800 men, 34,500 boys, 222,700 women, and 30,400 girls. On November 3, 1924, the number of unemployed persons was 1,228,023—937,975 men, 35,399 boys, 223,524 women and 31,125 girls; and on December 31, 1923, 1,285,623—946,521 men, 36,659 boys, 267,373 women, and 35,070 girls.

Among the 11,508,000 workpeople insured against unemployment under the Unemployment Insurance Acts in Great Britain and Northern Ireland, the percentage unemployed at October 27, 1924, was 11·1, compared with 10·8 at September 22, 1924, and 11·7 in October, 1923. Among the members of those trade unions from which returns were received by the Ministry of Labour, the percentage unemployed was 8·7 at the end of October, 1924, compared with 8·6 at the end of September, 1924. The total number of persons registered at Employment Exchanges in Great Britain and Northern Ireland as unemployed at October 27, 1924, was approximately 1,247,000, of whom 943,000 were men and 235,000 were women, the remainder being boys and girls; at September 29, 1924, the total was 1,243,000, of whom 936,000 were men and 234,000 were women; and at October 29, 1923, it was 1,340,000, of whom 994,000 were men and 263,000 women.

The principal industries showing a decline in employment in October were coal-mining and some branches of the clothing trades; in the cotton, furnishing and pottery trades some improvement was reported. Employment was good in the tinplate, steel sheet, brick, carpet, and jute trades, with mill-sawyers, coopers, and most of the skilled operatives in the building trades; it was fairly good in the silk trade, the furnishing trades and some branches of the printing trades, and fair, on the whole, in the leather and pottery industries, and in certain branches of the metal trades. In the coal-mining industry employment was slack; at iron mines, at iron and steel works, and in the engineering and shipbuilding trades, it continued bad.

According to the *Ministry of Labour Gazette*, the average level of the retail prices of food continued to rise during October. As a net result of all the changes recorded, the average increase over the level of July, 1914, rose to about 79 per cent. at November 1, as compared with about 72 per cent. at October 1, 1924, and 73 per cent. at November 1, 1923.

The membership of the Amalgamated Engineering Union continues to decline. According to the November issue of the organisation's "Monthly Journal," there was a decrease of 2,680 in October, the total falling from 247,131 to 244,451. Unemployed members were fewer, but the percentage—8·40—is still high. It is officially announced that on a second ballot Mr. J. Bowman has been elected Tyne district secretary by 2,195 votes to 1,736 votes cast for his opponent, Mr. M. Gladsden.

The unemployment figures of the United Pottermakers' Association are higher than they were in September. The increase is, the general secretary states, the organisation's chief concern, and any effort or suggestion made by members with the object of improving the position will earn the executive council's "deepest gratitude and thanks."

An increase in the number of unemployed members is also recorded in the November "Report" of the United Society of Boilermakers and Iron and Steel Shipbuilders. The number of members "signing the books" at the end of October was 21,467 as compared with 18,706 a month earlier. The expenses for October were 102,719*l.* 12*s.* 1*d.*; in September they amounted to 77,326*l.* 11*s.* 8*d.*

The executive council of the United Patternmakers' Association announce that they have "endorsed the attitude" of the General Council of the Trades Union Congress towards the Committee on Industry and Trade. The General Council's attitude is explained in a letter from Mr. Bramley which is printed in the U.P.A. November report. The communication is as follows:—

"The terms of reference of this committee are very comprehensive and include an inquiry into British productive capacity and organisation, including the supply and efficiency of capital, labour and management; also an inquiry into methods of industrial remuneration, the main causes of unrest, and disputes, as, for example, co-partnership, co-operation, wages boards and voluntary arbitration, State regulation of wages, compulsory arbitration, and compulsory enforcement and extension of agreement."

"The General Council have been asked to give evidence before this committee. They have, however, decided that as they were not in any way consulted as to the appointment of representatives to the Committee on Industry and Trade, nor at any stage were their views sought with regard to the extremely wide terms of reference, they are not prepared to submit evidence to the committee or to take part in any way in the inquiry."

"The General Council also decided to inform all affiliated unions accordingly, as it is understood that the views of certain affiliated organisations are being sought by the Committee on Industry and Trade."

At the fourth meeting of the Committee on Industry and Trade held on November 12, evidence was taken from Mr. W. A. Appleton, Secretary of the General Federation of Trade Unions, who gave evidence on behalf of the Federation. Mr. Appleton suggested that in view of increasing competition British industry must reduce its costs of production in order to avoid lowering the standard of living in this country. Without discussing in detail all the factors entering into cost of production, his opinion was that labour costs could not be further lowered, but that higher standards of organising and directive capacity as well as of manual effort, were required. As regards the other factors, he suggested that the cost of insurances could be lowered, that the number of commissions charged between the producer and the consumer should be reduced, and that the burden of rates and taxes was still too high. In regard to distribution, Mr. Appleton advocated the creation of new open markets for the supply and distribution, particularly of foodstuffs; the improvement and cheapening of transport facilities, and, in particular, State control and development of waterways.

The General Federation, he stated, had given very serious attention to the relations between the parties engaged in production, and wished to stress the desirability of developing the human side of industry by making intelligent workpeople parties to the business rather than mechanical parts of it. Mr. Appleton further mentioned the desirability of securing, under proper safeguards, the enforcement and extension of voluntary agreements between employers' associations and trade unions. In conclusion, he recommended that in connection with industrial disputes the appointment of a Court of Enquiry should be more frequently resorted to; and that machinery should be set up by the employers' associations and the trades unions for the wider diffusion among the workpeople of industrial and commercial information.

According to "Russian Information and Review," Moscow, both town and province, is the most important centre of the trades union movement in the U.S.S.R. The membership of the trades unions in the area, rose, it is stated, from 819,668 in 1923 to 910,098 in 1924. The latter figure includes 72,348 unemployed, and 39,788 student workers. Women constitute 37·3 per cent. of the total membership, and the proportion of women taking part in the administration of the non-manual workers' unions is greater than in the manual workers' unions. Much important organising work has been done among the workers generally. The local factory committees have been re-organised, factory commissions have been set up to deal with special questions, and delegate meetings have been held in order to study ways and means of raising the productivity of labour, trades union organisation, unemployment, and other questions.

On August 1, 1924, 725,232 members were covered by collective agreements, including 15,000 domestic servants, whose work was regulated by individual labour agreements, and 10,000 day labourers in the villages. The wages of the members of all the unions have increased, the average rise between October, 1923, and June, 1924, being 15 per cent. In a number of instances, Moscow wages are now above the pre-war level. Those of the Moscow metal workers are 97·4 per cent. of the pre-war figure, those of the textile workers 102 per cent., those of the chemical workers 109 per cent., those of the food workers 113 per cent. those of the press workers 103 per cent., and those of the leather workers 140 per cent. During this period the unions have, it is added, taken an active part in the endeavours made by the Soviet economic departments to improve industrial undertakings and increase output.

The trouble in the tramways industry has been adjusted on the lines suggested by the Tribunal, which recently investigated the claims of the men. At a meeting in London on November 13, the National Joint Industrial Council unanimously adopted the decision and report of the Tribunal on standardisation, grouping, stabilisation, and night rate payment, and decided to recommend all the interests concerned to operate the new terms as from November 18. A question of detail, *viz.*, the classification of shed, depot and repair staffs into three grades, was left over for further consideration. The Tribunal's report provided that this matter should form the object of local negotiations and that in the event of failure to agree there should be a reference back to the National Council.

The National Joint Council for the Electricity Supply Industry met in London on November 14 to consider the report of the Special Tribunal set up to investigate the men's claim for an advance of wages of 10 per cent. An official report issued at the close of the meeting stated that the National Council had decided to "put into operation recommendations *b*, *c*, *d* and *e*, of the Tribunal with the exception of the latter part of recommendation *e*, under which there might be a further reference to the Tribunal." The effect of this is that the question of wage adjustments will go to the various areas for consideration and settlement. In the event of failure to agree in any area the question will be referred back to the National Council. The part of the Tribunal's report which has not been adopted is that relating to the constitution of the Tribunal in the event of the National Council being unable to reach a conclusion on an area agreement.

THE INSTITUTION OF MECHANICAL ENGINEERS.—H.R.H. The Prince of Wales has kindly consented to honour the Institution of Mechanical Engineers, of which he is an Honorary Life Member, by attending the annual dinner of the Institution at the Connaught Rooms on Thursday, December 18.

STEEL CONSTRUCTION WITH THE USE OF TUBULAR MEMBERS.—In last week's issue of ENGINEERING (*see* page 674), a system of steel construction was described in which use is made of tubular members. In connection with this, we are asked to announce that Mr. I. G. Richards, of 15, Ladbroke-square, London, W.11, has been appointed sole agent for the British Empire by the inventors, Messrs. W. J. van der Kloet and W. A. L. Stift.

THE BRITISH INDUSTRIES FAIR.—In view of the probable re-opening of the British Empire Exhibition in 1925, it has been decided to suspend the London Section of the British Industries Fair, which would otherwise have been held from February 16 to 27. The Birmingham Section of the Fair, will, however, be held as usual and as a special measure for 1925 only, the Birmingham Authorities have generously undertaken to organise sections in their Fair for those exhibitors who have hitherto shown in London, provided that the demand for space ensures the adequate representation of the industries concerned. The Department of Overseas Trade expects to resume the series of British Industries Fairs in London in 1926.

SCHOLARSHIPS IN ENGINEERING.—The Council of the British Electrical and Allied Manufacturers' Association have recently granted the following scholarships and renewals of scholarship tenable for one year, each of the value of 100*l.*, together with the payment of college fees:—*In Electrical Engineering.*—J. T. Birtwell: Tenable at the College of Technology, Manchester. G. E. G. Foden: Tenable at the College of Technology, Manchester. P. J. Maggs: Tenable at the City and Guilds (Eng.) College, South Kensington. H. G. Richards: Tenable at Birmingham University. R. Robinson: Tenable at Durham University. *In Mechanical Engineering.*—J. C. Burke: Tenable at the College of Technology, Manchester. *Renewals of Scholarship.*—A. B. Everest: Tenable at Birmingham University. Mr. Everest won a B.E.A.M.A. scholarship in 1923 in the subject of metallurgical research in relation to electrical engineering and obtained his degree. I. H. Hedley: Tenable at Durham University. Mr. Hedley won a B.E.A.M.A. scholarship in 1922 in the subject of electrical engineering. G. S. C. Lucas: Tenable at the City and Guilds (Eng.) College, South Kensington. Mr. Lucas won a B.E.A.M.A. scholarship in 1923 in the subject of electrical engineering. B. S. Pelton: Tenable at the University of London. Mr. Pelton won a B.E.A.M.A. scholarship in 1923 in the subject of mechanical engineering.

ROADLESS TRACTOR.

CONSTRUCTED BY THE SENTINEL WAGGON WORKS (1920), LIMITED, SHREWSBURY.

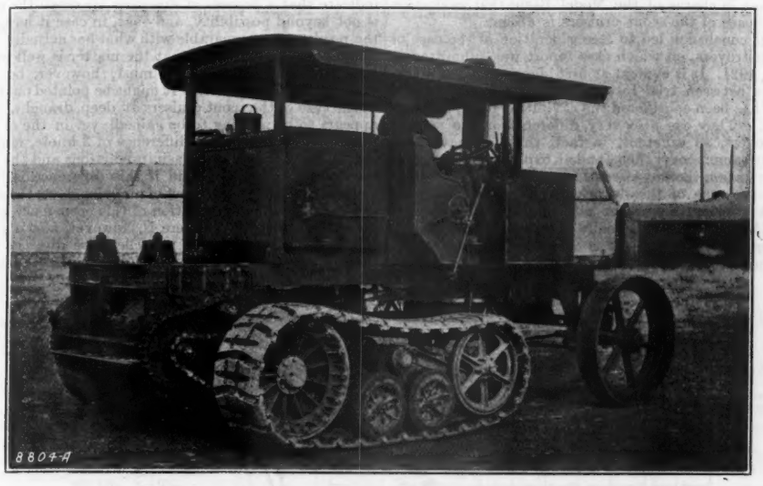


FIG. 1.

FIG. 2.

THE "SENTINEL-ROADLESS" TRACTOR.

In many places, especially in overseas territories, goods must be conveyed long distances either over open country, or on roads which were originally built for much lighter service and which are now completely broken up. Steam wagons and motor vehicles of the ordinary type cannot be run with success under such conditions, and the manufacturers are therefore now devoting themselves to the construction of track systems so that their standard machines may be modified to meet this more difficult service. As an indication of what has been achieved we may refer to a demonstration which was held recently at Shrewsbury by the Sentinel Waggon Works (1920), Limited, when a Super-Sentinel steam tractor, fitted with a track-laying equipment was driven over open and uneven country, and through mud and ponds. The accompanying illustrations show this new tractor, which has a total weight of 7½ tons. It was propelled across soft land hauling heavy tree trunks, and drew along the road a train of miscellaneous vehicles weighing 58 tons. The drawbar pull was measured by means of a dynamometer, and amounted to almost 6 tons. The climbing and descending of gradients was demonstrated on a piece of land which is in process of being filled in to the general level of the works of the company. The ground was soft, and consisted mainly of slag and cinders. No difficulties were, however, experienced in negotiating the rises and falls, which were as steep as 45 deg. in some parts. Passage through a pond was made, and the slimy character of the soft clay bottom was manifest from the matter which adhered to the track on the completion of the journey. The manner in which the tractor could be driven over tree trunks was also shown, and is illustrated by Fig. 2. All the tests proved completely successful, and the way in which turning was accomplished without any appearance of side slip or skidding was made apparent by the impressions created by the track plates.

In this tractor the boiler is carried towards the forward end of the chassis, while the engine is over the centre of the two tracks, and the coal bunker and feed-water tank are accommodated above the engine. This arrangement gives a concentration of load on the track, where there is ample bearing surface, and leaves the front wheels but lightly loaded, in order that any tendency to dig them into soft ground may be avoided. In front of the apron plate, which surrounds the boiler, there is provided a winding drum driven by an independent engine which can be used either alone or in association with the main engine and track in getting out of very bad ground. We have already described, with the use of many figures, showing details, the boiler and engine of this tractor, and reference may be made to the earlier article in ENGINEERING (vol. cxvi, page 694), for a complete description of these. It is of interest to note that the Sentinel Waggon Works (1920), Limited, are now producing similar engine and boiler sets as economical portable units for use in sawmills, electric light plants and for the many other purposes for which an engine of about 60 h.p. is suitable.

As this tractor is of the "half-track" type, the front wheels, but lightly loaded, are available for steering. The power is transmitted from the engine to the tracks by means of silent roller chains. A small sprocket with its shaft accommodated inside the hollow crankshaft of the engine, is coupled by a chain to a larger one, free to revolve on an intermediate stationary jackshaft. This pinion is bolted to a smaller one which drives the chain drum connected to the main driving sprocket of the track, by means of a heavy chain. There is no complication in this drive and it is, of course, duplicated so that motion is obtained for the two tracks. Chain wear adjustments may be made at any time, as the jackshaft may be immediately set in any position, back or forward. Lubricators are fitted to the chain so that undue wear of these important components is prevented.

The tracks are made by Messrs. Roadless Traction Limited, of Hounslow, and are the outcome of experience gained with tanks in the European War. The links of the track are made of high tensile forged steel and are hollow, to provide a receptacle for lubricant, and have their driving teeth in the centre. The tracks are electrically welded to steel shoes, which form paths on either side of the links, on which the rubber tyred rollers run. Lugs on either side of the roller paths are used to limit the movement between the shoes to the requirements. The track joints consist of hardened and ground steel pins, working in bushes of the same material. The bushes are made partly spherical on the outside, and around them the machined portions of the link are pressed with dies to obtain the limited universal movement which is required. By the pressure of the dies the pressed-over portion of the link is given a suitable inner surface, where it surrounds the bush. On the outer surfaces of these parts seal rings of compressed coke composition are provided, and these are reinforced against injury by surrounding them with metal rings. Effective lubrication is provided at the joints, and the provision of the seal rings prevents the entry of grit or loss of oil.

The sprocket which engages with the teeth formed on the top of the links is designed so that the teeth in contact with the sprocket at any time take an equal share of the work, and thus, are each subjected to a light load. Rubber tyres fitted to the sprocket, cushion the engagement of the teeth and reduce the noise of action at height speeds. The idler wheel carrying the track at the forward end is also rubber shod.

Each bogie carries four rubber tyred cast-steel rollers, mounted on Hyatt bearings. These rolls have flanges, which by contact with the sides of the track links, keep the bogie in correct alignment with the portion of the track, which is on the ground. As the bogies are universally mounted in a bracket carried by the axle, they accommodate themselves to the angles assumed by the track plates on uneven ground. Also, it should be noted, that the universal mounting permits the bogies to swivel as though they were on vertical pivots, which is of great service when the vehicle is turning. The load of the vehicle is carried to the bogies through semi-elliptical springs and the axle which carries the brackets on which the bogies are mounted.

When steering, each track plate is laid on the ground at an angle to the one which previously reached the ground. The results of this is that slip or skidding over the ground surface is eliminated. The action of the track in accommodating itself to the requirements of turning was well shown at the demonstration by running the vehicle round a curve on a piece of hard ground covered with sawdust. The impressions left on the surface showed the flexibility of working that is attained, and bore out the contentions made that the destructive action of steering by skidding is completely eliminated. Brakes are fitted to drums mounted with the main driving sprockets, and these are of the internal expanding type with Ferodo linings. In addition there is an engine brake by the use of which the power unit may be converted temporarily into an air compressor when the motion of the vehicle has to be checked in going down a declivity.

THE EXTENT OF CAVITATION IN U.S. SCOUTS AND DESTROYERS.*

By Captain E. F. EGGERT, C.C., U.S.N.

It has been the opinion among naval architects that when propellers reach a certain degree of overloading, a phenomenon known as cavitation begins to

* Paper read at the meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 13 and 14, 1924.

make itself felt and becomes more important as the overload increases. This cavitation has been described by some writers as the formation of cavities on the backs of the blades; by other writers as cavities on the face, or face and back; and other descriptions have been given. Under certain exaggerated conditions, this cavitation has been experimentally produced and been made visible to the eye, its chief characteristics then depending on the particular exaggeration of the conditions. Various authorities have assigned a tentative limit for normal design of propellers at which cavitation might be expected to begin, this limit, in the case of one well-known authority, being given as 10,000 ft. per minute tip speed.

With this assumption, it was fully expected that the propellers for the destroyers built during and since the war, and also those for Scout cruisers Nos. 4 to 13, would show decided effects of cavitation; these effects are defined as a progressive divergence between trial powers and revolutions at given speed, and the corresponding powers and revolutions deduced from model experiments. These divergences in the cases of the destroyers at higher speeds were quite large and were extensively discussed in Model Basin reports in 1921 and earlier. The later destroyers having a tip speed of about 12,000 ft. per minute and the scout cruisers a tip speed of over 13,000 ft. per minute, it was expected that the standardisation trials of the latter would indicate equally great divergences; and it was surprising to find, when three of these vessels were standardised, at their contract displacement of 7,200 tons, that the divergences were relatively small; in fact, in the case of the Omaha, so small as to be nearly non-existent. Still more surprising, however, was it to find that when standardising at deeper draughts, corresponding to about 8,300 tons and 9,500 tons displacement, they showed less divergence from the Model Basin results, and in the case of the deepest draught almost none. These latter trials were of the Richmond, which had on light draught shown the greatest divergence.

These results were so remarkable that the Model Basin experiments were repeated a number of times. In all, five separate series of runs were made with the model self-propelled at light draught, and two sets each at the deeper draughts. All of these results are plotted on the annexed Figure. The curves shown are the results of the Model Basin experiments and indicate the degree of precision that may be expected from such work. The spots plotted are the trial spots as reported by the Trial Board.

It is evident that cavitation, as it is usually described, cannot be the cause of the differences shown in the case of these cruisers, for had there been cavitation, which means a departure of the streams of water from the surfaces of the propeller blades, such cavitation would have become worse at a given speed as the displacement increased, because the thrust of the propeller would increase and therewith the slip and slip angle. On the contrary, the divergence became less as the displacement increased until, at the deepest displacement, it had almost disappeared. There is a further peculiarity in these results, in that the Omaha, at light draught, showed less divergence than the other two cruisers; in fact, almost none. Investigation showed that there was a significant new condition of the trial in the case of the Omaha in that she was run trimmed considerably by the stern. In other words, the propellers had more submergence than those of the other two cruisers. It is, of course, evident that this submergence of the propeller increases also as the displacement of the ship is increased.

It is plain that cavitation does not fit as an explanation of the results of these trials, and another explanation must be sought. Cavitation depends only on the relative speed and direction of the stream past the propeller surfaces and is not changed appreciably by change in submergence. In this case, however, it seems that submergence was the controlling factor and not the degree of loading of the propellers. The only factor that can thus influence the performance of the propeller as its submergence is changed is the introduction of air into the propeller disc. It was noted in the early days of the design of the scout cruisers that air could be, at times, drawn down along the rear edge of the propeller struts, in the model. At the light contract draught, the upper strut palms are very near the surface when the vessel is on an even keel, and when account is taken of the stern wave and the change of trim at full speed. Considerable eddying must be set up by this strut palm and the strut below it, especially in slightly disturbed water, and there would at once be opened an air tube, which, at increasing speed, would extend farther and farther down until air was introduced into the disc. This was experimentally shown on a model in the Basin, as will be described below. The eddy increased in depth as the speed increased, and the great increase in divergence, as shown in this test, was, therefore, to be expected with the increase of speed. Again, if the vessel at light draught is down by the stern, this divergence would be later in appearing, and the same thing applies if the vessel is given increased draught throughout. In other words, although the actual happening in this case was directly contrary to what might be expected from cavitation, it agrees in all respects with what may be expected from the introduction of air to the propeller disc, through eddies forming behind the strut, and it is becoming the opinion of those in charge of the Model Basin that cavitation in the case of the scout cruisers is absent.

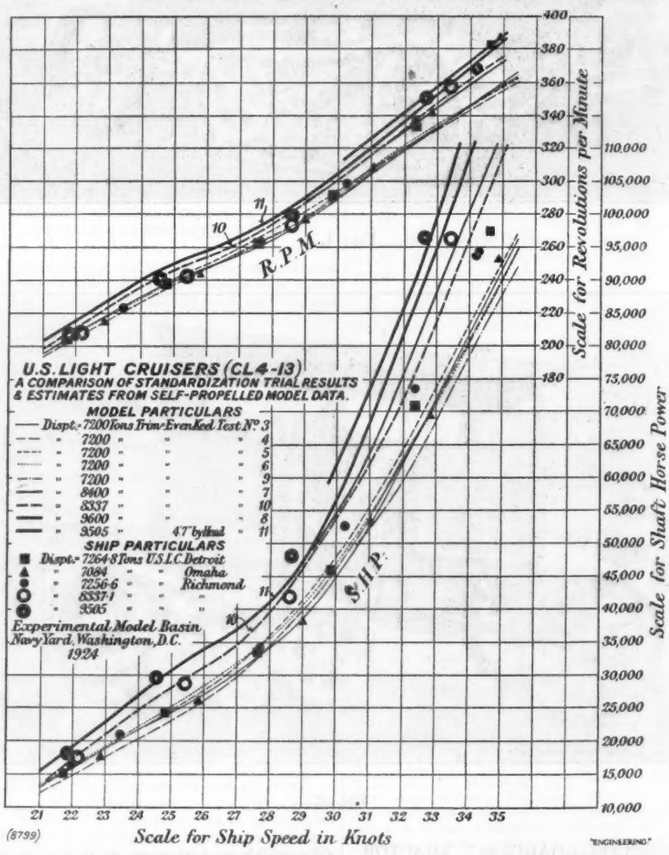
This conclusion led to reconsideration of the case of the destroyers, on which case report was submitted in June, 1921. It is evident at first glance that the divergences between trial results and basin results, above what has been considered the cavitating limit, are very great. They are also very different for the various destroyers, so different, in fact, that the cavitation theory cannot cover them, and an explanation by means of cavitation therefore seems very doubtful.

In the case of the destroyer, the upper strut arm breaks the surface under all conditions, and eddies form behind the strut, finally allowing air to get down to the propeller disc. It is clear that the amount of eddying or the size of the air tube must be greater than in the case of the scouts, where the strut only approaches the surface. Furthermore, small changes in the shape of the strut section, or how it is set regarding the fore and aft line, might make considerable difference, and a well-formed and smooth strut might give worse results, if it is not aligned correctly, than a rough and ill-formed strut, which is placed in the proper streamline. But, generally speaking, a small difference in the bluntness of the after edge of the strut should show a considerable difference in the results.

To test this idea of the divergence being due to air being directed down behind the propeller strut, one of the destroyer models was fitted up as before for self-propulsion, but the after edge of the strut was blunted and its thickness increased, more or less, in various experiments, up to a maximum of $\frac{1}{8}$ in. When this model was run self-propelled the phenomena described above, in connection with air being drawn down through the eddy, were easily observed. As soon as a certain definite speed was reached, the eddy behind the strut would form and would go deeper and deeper as the speed was increased until it reached the propeller hub. At this point there seemed to form a continuous sheet of air between the strut and the propeller disc.

Measurements of powers and revolutions, and the corresponding prediction for full size, show, in the case of the thickest strut edge, divergences from previous results, quite similar to those shown in the trials of the vessel. The divergences were, however, considerably greater. In the case of the smaller thicknesses experimented with, these divergences were only small. It appeared that a definite size of air tube was necessary to bring down sufficient air to affect the results considerably.

While these experiments are not conclusive, they indicate that a process of directing air down the strut is not beyond possibility, and that, in case it happens, the results are, comparable with what has actually been found on trial. It seems that the matter is well worth further experiments, which must, however, be performed on full size vessels. It might be pointed out that, in the case of the scout cruisers at deep draught, there appears to be nothing to be gained, yet in the case of the destroyers there is a difference of 3 knots, more or less, between the Model Basin predictions and the trial results, for full power, and if this difference is to be entirely ascribed to the effect of air going down the strut, it would seem that prevention of this occurrence would be well worth while. There is, however, also a possibility of air entering the propeller disc directly from the surface, over the tips. This has sometimes occurred


U.S. LIGHT CRUISERS (CL4-13)
A COMPARISON OF STANDARDIZATION TRIAL RESULTS & ESTIMATES FROM SELF-PROPELLED MODEL DATA.
MODEL PARTICULARS
Displ.- 7200 Tons Trim-Even Keel Test N°. 3
7200 " " " 4
7200 " " " 5
7200 " " " 6
7200 " " " 9
8400 " " " 7
8337 " " " 10
9600 " " " 8
9505 " 4.7 by keel " 11
SHIP PARTICULARS
Displ.- 7264-8 Tons U.S.L.C. Detroit
7084 " " Omaha
7256-6 " " Richmond
8337-1 " " "
9505 " " "
Experimental Model Basin Navy Yard, Washington, D.C. 1924
R.P.M.
S.H.P.
Scale for Revolutions per Minute
Scale for Shaft Horse Power
Scale for Ship Speed in Knots
(8799)
"ENGINEERING"

To avoid having the air travel down the struts, in the case of the destroyers, it is evident that nothing can be done in the way of fining the strut arms. In new design, it is probable that the best results would be obtained by the suppression of the upper strut arm, increasing the lower one sufficiently to take the weight. It is considered that in all new designs of any class of ships at high speed, this question should be given careful consideration.

Assuming that the above explanation holds, for these two classes of vessels, a new field of usefulness appears to have been opened for the Model Basin. Under such circumstances, it would appear that the Model Basin predictions for high-speed vessels might be considered correct up to the highest speeds, if the strut design has been correct. Furthermore, it appears that any empirical corrections of Model Basin power and revolution predictions would be decidedly uncertain, if they are dependent on the amount of air that is directed down to the propeller discs, and that any method of prediction of propeller performance, which includes an estimate of cavitation, should be well reconsidered.

THE ELECTRIC ROAD VEHICLE.*

Its Characteristics and its Economic Field of Usefulness.

By D. E. Batty.

(*Concluded from page* 690.)

The Battery.—The success of the self-propelled electric vehicle is largely dependent on the satisfactory performance and life of the battery, and one which may be quite suitable for stationary work may soon fail, owing to weakness of construction, to the heavy draw of current necessary for traction work, and also owing to the vibrations of the road. Developments have taken place in two directions, namely in the lead-acid type, and the nickel-alkaline type, and these developments have now enabled the manufacturer to give guarantees for the life of their batteries for traction work.

The Lead-Acid Type.—The flat-plate type of lead-acid cell has been developed to a high state of efficiency and durability both here and in the United States. The Chloride Company has gone a step further in producing their "ironclad-exide" type. In this type the positive plates consist of armoured pencils homogeneously connected in parallel rows to form plates, superseding the flat type of positive electrode, and increasing their useful service period by at least 100 per cent. The positive plate is particularly mentioned here, because the life of the lead storage battery is usually determined by the life of the positive plate. The active material of the positive plate has less cohesion than the material of the negative plate, and during the life of the battery this positive material tends to soften and eventually to fall to the bottom of the cell in the form of sediment. Each lead-type cell gives an average voltage of 2, and from 42 to 44 cells are usually used on electric vehicles with 80-volt motors. A fully-charged battery will give an initial voltage of 2·2 volts per cell on discharge for a short period, and then will drop to 2 volts for the main period of discharge, after which it will drop to 1·8 volts per cell, when the battery is considered to be discharged. The state of the electrolyte in the battery plays an important part in the chemical changes that take place during charge and discharge. When fully charged the specific gravity of the liquid is about 1·25, and when discharged it will be about 1·12; it serves, therefore, as an indication as to the state of charge of the battery.

The Nickel-iron Battery.—In the nickel-iron battery the positive plate is nickel oxide, the negative plate finely-divided iron, and the electrolyte a dilute solution of caustic potash. Such a cell has a nominal voltage of about 1·2 volts per cell. On discharge, the iron of the negative plate is reduced to iron oxide, the positive plate (nickel oxide) furnishing the oxygen, while the electrolyte acts as a carrier to carry the oxygen from the positive to the negative plate. The electrolyte does not directly enter into the reaction, nor does its specific gravity change during discharge, and it therefore has no significance in regard to the state of discharge of the battery. The manner in which the electrolyte acts as a carrier may be considered in this way—the water in the electrolyte is split up into oxygen and hydrogen, the oxygen oxidises the iron in the negative plate, while the hydrogen combines with a corresponding amount of oxygen at the positive plate, reducing the higher oxide of nickel to a lower oxide, the combination of the hydrogen with the oxygen forming water to replace that broken down. On charge the reverse action takes plate. A fully-charged cell will give an initial voltage of 1·5 volts, after which it will maintain about 1·2 volts till it falls to 1 volt, when it is considered discharged. The standard number of cells usually employed on battery vehicles is 60, and the motors are generally rated at 60 volts. Table III is a comparison of the chief features of lead and iron batteries.

Battery Charging.—The usual pressure on the supply mains is 220 volts for lighting, and 440 volts for power on direct-current circuits, while alternating current is supplied at various voltages and frequencies. With either alternating or direct current the pressure will have to be transformed to that suitable for battery charging. It is not within the scope of this paper to discuss the methods of transformation, but rather to indicate the method of applying the current to recharge the battery. As previously stated, the lead-battery voltage drops to 1·8 volts per cell, and on a 44-cell battery the voltage will be 79·2 volts. The charging voltage will have to be higher than this, and will in fact depend on what rate of charge is considered most efficient. It is a well-known fact that a lead battery will stand a high rate of charge at the outset, but that the rate has to be cut down as the charge proceeds. (Traction-type lead batteries are generally rated for a discharge rate of five hours.) This can be done by the two-step method, by which the charging-current rate is determined by the size of the cells, and this current maintained till the cells gas freely, when the charge is reduced by hand. A better way, in the author's opinion, is the constant-voltage method. By this method the voltage of the charging plant is adjusted to about 2·3 volts per cell (101·2 volts for 44 cells). On the first application of this voltage the current into the battery is very high, but the counter e.m.f. of the battery rapidly rises and the current is reduced, and steadily diminishes till the current gets very small, when the voltage is raised to about 2·6 volts per cell, which completes the charge. If, with this system, a small fixed resistance is connected between the battery and the generator, the charging will be automatic. The voltage of the generator is adjusted so that, with a small charging current, it is high enough to complete the charge. At the commencement of the charge, when the battery pressure is low, the voltage drop across the resistance will prevent too high a currrent passing. In this connection, it may be mentioned that Messrs. C. A. Vandervell, in conjunction with the author, have developed a constant-voltage bus-lighting dynamo, which consists of a plain shunt-wound dynamo with a voltage regulator (of the Tyrrel type) mounted on the switchboard. The output of this generator is 350 watts, and the regulator is so compounded that the voltage rises as the current into the battery diminishes. In practice, its action is to supply current to the battery in accordance with its needs—a heavy current if the battery is slow, and a small current if the battery is up. With this system the consistent overcharging that takes place with automobile generators of the third-brush type is done away with, and battery maintenance is much improved. The charging of the nickel-iron battery can be dealt with in the same way, but the voltage range has to be suitably adjusted. The nickel-iron battery has a voltage of about 1·85 volts per cell when the charge is completed, and a constant voltage of 1·67 can be applied.

Table III.—*Comparative Technical Data.*

	Lead Battery. At 5-Hour Rate of Discharge.	Nickel-Iron Battery. At 3-Hour Rate of Discharge.
Efficiency, ampere-hour ..	80-85 per cent.	75-80 per cent.
,, watt-hour	70-75 per cent.	55-60 per cent.
Charging volts at end of charge	2·6	1·84
Volts at end of discharge ..	1·76	1·0
Average volts during discharge	1·95	1·2
Ampere-hour capacity, per lb. of complete battery	4—5	10—12
Watt-hour capacity, per lb. ..	8—9	8·5—15
Guaranteed life	2 years.	8 years or 60,000 miles.

The Economic Sphere of Usefulness of Electric Vehicles.

The economic sphere of electric vehicles may be considered from two points of view: (*a*) the direct economies in running cost and maintenance, &c.; (*b*) the indirect economies in time and labour saving effected by vehicles peculiarly adapted to the work in hand.

The author has found it impossible to obtain practical working costs for battery vehicles from private companies, apparently due to keen competition and to the important part played by delivery costs. Corporations and municipalities, on the other hand, are profuse in the figures which they publish, but these are very involved, and are almost impossible to compare on a common basis. It is, therefore, proposed to give such working costs in a comparative way, from the study of such information as the author has been able to obtain.

Before the economic side can be studied, electric vehicles must be considered according to their physical limitations. The battery vehicle is chiefly limited by the capacity of the battery carried, and this affects its radius of action, and also its maximum speed. The battery is usually rated to give a radius of action from 30–50 miles per charge, depending on the service, road surfaces and grades. The maximum speeds range from 14 to 15 miles per hour, for the smaller cars, to 9 to 10 miles per hour for the heavier vehicles. Where the service demands frequent starting and stopping, maximum speed is not so important as high acceleration, and this is where the electrically-driven vehicle excels all other types of road vehicles.

Another limitation of the battery vehicle is the means by which its stored energy is replaced. Batteries take several hours to charge, and unless stand-by charged batteries are available, the service must be arranged so that the battery can be charged when the vehicle is off duty. With the increasing use of electricity the difficulty, if any, of getting a charge will be overcome, and also the cost of the charge will be less. From these considerations it is obvious that the sphere of usefulness of the battery vehicle lies in such service conditions as demand frequent stops within a radius limited by the battery charge that will bring it back to its charging station.

Town deliveries of goods of all kinds by private companies, &c., and municipal service in the house-to-house collection of refuse may be mentioned as suitable spheres for battery vehicles. There is one sphere of usefulness in which the battery vehicle has no competitor namely, the small industrial truck used in factories and on railway platforms. The reason for this is its great flexibility, while, further, it does not vitiate the air with exhaust fumes, and, therefore, can be used in confined spaces and underground passages or tunnels. These trucks run on rubber tyres on "road" surfaces of concrete or wood or asphalt, and work more or less in the same way as their larger brothers of the highway. They have innumerable uses, and are often constructed for quite special jobs. Among some of the special designs may be mentioned the Ransom electric runabout crane. Another design, made by Electricars, Ltd., is an electric tipping truck, specially made for dealing with boilerhouse refuse, coke, &c. These, then, are the spheres of usefulness of the battery vehicle as dictated by physical conditions.

The sphere of usefulness of the trolley-bus is determined by the supply of electricity from an outside source, and by the overhead wires to which it is confined. This limits it to predetermined routes, and, consequently, it is only used for passenger transportation. Its use has, therefore, been developed by tramway companies and municipalities, who have the available supply of electricity and who have the overhead wires already provided. The author would like to point out that, in addition to the comparisons already made by Mr. Taffs between the trolley-bus and the tramcar,* the latter, running on rails, operates with a lower rolling resistance (15–20 lb. per ton), but, on the other hand, owing to the question of adhesion, the dead-weight of the tramcar has to be much higher than that of the trolley-bus. It is generally found that the dead-weight of the tramcar is about double that of the trolley-bus, but, having only half the rolling resistance, the current consumption per car-mile is approximately the same. In a paper read before the Congress of Tramways and Light Railways Association, at Bournemouth, some years ago, Mr. E. M. Munro gave an interesting comparison showing the weights per passenger carried for different classes of vehicles.

The weights he gives are:—

		Average Weight per Seat. Lb.
Trolley-bus,	single-decked	355
,,	double-decked	297
Tramcar,	single-decked	896
,,	double-decked	440
Petrol bus,	single-decked	296
,,	double-decked	256

The seating capacity of tramcars is usually greater than that of trolley-buses, and they also have a greater overload capacity, and for this reason they hold the field in densely-populated districts, where a very frequent service is demanded. In order to meet this demand tramway managers have of recent years put into service large double-deck trolley-buses, as instanced by the vehicles installed in Birmingham and Leeds and Bradford. The petrol-electric vehicle can generally be classified with the straight petrol vehicle in its freedom of action, but it has in addition a sphere of usefulness peculiarly its own. It is a small power station in itself, and can be used for a number of purposes, such as searchlights for army use, or running pumps on other machinery at a short distance from the vehicle.

Having broadly stated the spheres in which the electric vehicle can be worked effectively, it will be well to classify next the types of services that are generally used for the transport of goods and passengers.

Class 1.	Goods.	House-to-house delivery with radius of 5 miles.
Class 2.	,,	Town and suburban delivery with radius of 10–15 miles.
Class 3.	,,	From town to town, 100 miles per day.
Class 4.	Passenger bus service with ½-hour headway.	
Class 5.	,, ,, ,,	¼-hour ,,
Class 6.	,, ,, ,,	10-min. ,,
Class 7.	,, ,, ,,	5-min. ,,
Class 8.	,, ,, ,,	3-min. ,,

From the limitations previously discussed, it can be said that battery vehicles are suitable for Classes 1 and 2. Class 3 is beyond the scope of battery vehicles. Class 4 can be served by trolley-buses, but the standing charges on the overhead equipment would probably be too high to ensure the economic success of the service. The petrol-bus is indicated for this service. Classes 5, 6, 7 and 8 can all be served by the trolley-bus, provided that the maximum length of route is within the economic supply of electricity. The supply of

* Abstract of a paper read before the Institution of Automobile Engineers on November 12, 1924.

* Proc. I.A.E. Vol. xvii, Part I, page 215.

5-B.H.-P. TWO-STROKE PARAFFIN ENGINE WITH MAGNETO IGNITION.

CONSTRUCTED BY MESSRS. PETTERS LIMITED, ENGINEERS, YEOVIL.

Fig. 1.

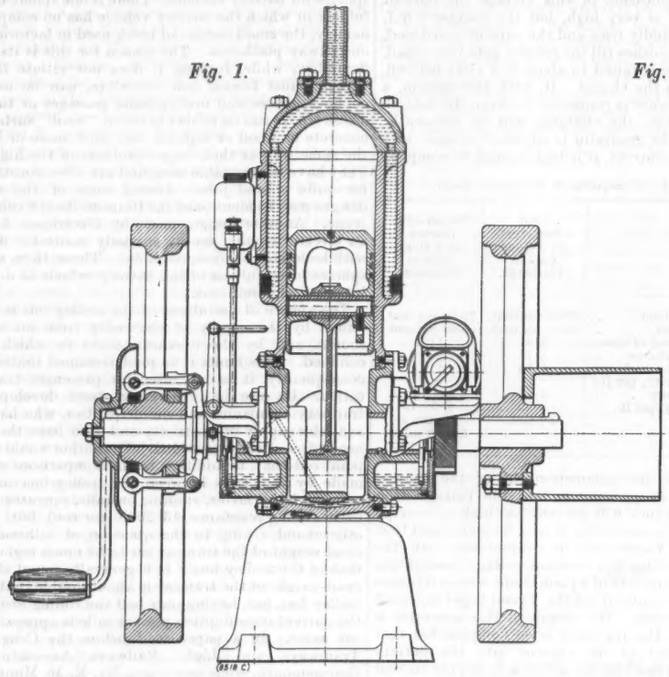
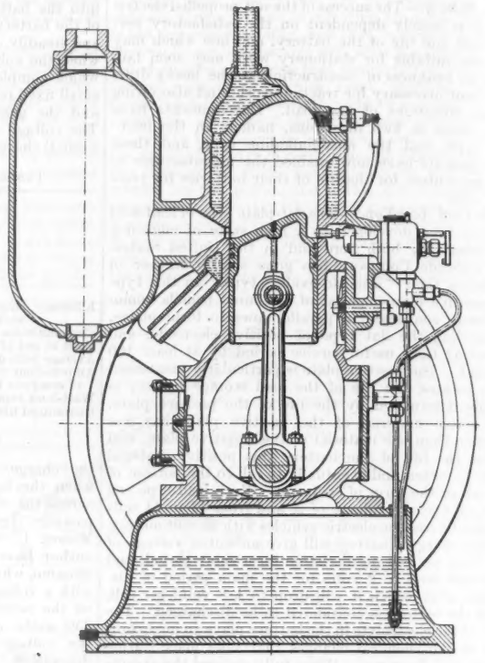


Fig. 2.



electricity is used for many other purposes, and will be distributed to a much larger extent in the future, so that it is fairly safe to assume that the current would be available where a trolley-bus service is desirable.

Mr. Taffs, in his paper on "Railless Trolley Traction,"* has compared very fully the operating costs of a tramway system with that of a trolley-bus. The author proposes, therefore, only to analyse the items that go to make up the working costs of petrol and battery vehicles on the most suitable basis for the electric vehicles, as determined by the limitations previously stated. Table IV gives the running costs of petrol and battery vehicles of similar carrying capacity, namely, 2½ tons. It will be observed that the capital cost of the battery vehicle is greatly in excess of that of the petrol car. This is mainly due to the high cost of the battery, and it will be also noted that the nickel-iron battery costs more than three times as much as the lead battery. The battery maintenance charges are based on the makers' guarantee, namely, two years for the lead battery, independent of mileage, and eight years or 60,000 miles, whichever limit is first reached, for the iron battery. This comparison shows a slight advantage in favour of the lead battery. On the other hand, owing to its very robust nature, the iron battery usually has a much longer life than the makers' guarantee. The lead battery, too, if properly used according to makers' instructions, will often exceed the guaranteed life.

Taking the capital cost of the petrol and battery car (with lead battery), it is shown that the latter costs 177*l.* more than the former, but the saving on operating costs per annum is 25*l.*, or 14 per cent. of the extra capital cost, which is not at all a bad investment. It may be said that the difference in operating costs is so small that the lower capital cost of the petrol car makes it a more attractive proposition.

Nothing has been said as to the comparative value of horse traction, but information on this subject can be obtained from Mr. Brookman's paper, read in 1916 before the Institute of Engineers and Shipbuilders in Scotland. Mr. Brookman, in comparing a fleet of 130 horses with a fleet of 52 electric vehicles of various load capacities, gives the figures shown in Table V.

A good deal could be said for the use of electric vehicles for municipal service, where the advantages of cheap electricity and the co-operation of their electrical departments gives additional facilities for the working of these cars. Tower wagons, for the repair of tramway overhead wires, dust carts, street sprinklers, &c., come within this category, and are in fact used in many centres.

With regard to the question of reliability, Mr. A. W. Blake, the engineer to the Willesden Electricity Department, reported in 1923 (the third year of operating these electric vehicles) that :—

"The total working time of the 14 vehicles was 33,830 hours, while the total time lost from breakdown, accident, or other causes was 32 hours, or equal to 0·095 per cent. of the total working hours.

"Six of the vehicles ran through the year without any loss of time.

"Several of the batteries have had to be renewed, but there are still six in use after three years' work."

A question of vital interest to tramway managers is the replacement of worn-out rails. If the total cost of reconstruction is capitalised, the standing charge per car mile will be represented by the interest and maintenance charges per annum (based on an estimated life of 15 years), divided by the total car miles per annum. The density of the traffic is the deciding factor which will warrant this expenditure, which for a trolley-bus or a petrol-bus service would be unnecessary. The crux of the whole matter lies in the passenger density per mile. Tram cars can carry a larger number of passengers than either the petrol-bus or the trolley-bus. In this respect the limitation of any vehicle is in the maximum weight per axle that is permitted due to road or track construction. The largest tram cars are constructed on bogie trucks with two axles each, so that the load is well distributed over four axles, which is twice as many as is usual in a road vehicle at present. It is impossible with the present limitations of road construction, and with the regulations of the Ministry of Transport, to construct a four-wheel road vehicle to carry the same number of passengers as the largest tram car will accommodate. On the other hand, the ratio of passenger weight to deadweight of vehicle is greater in the road vehicle than the tram car if the normal seating capacity is taken. Tramcars, however, can usually take a larger overload. From this it is probably right to say that where the traffic is very dense there is still scope for the tramcar. In less dense and outlying districts, the road vehicle, free from the enormous capital cost of providing its own road (although it pays a share in taxes), is undoubtedly, the more economical.

This, then, is the tramways manager's problem. He has the choice of two alternatives, namely, petrol or trolley-buses. It is natural that he should turn to the electric vehicle; the power station and a cheap supply of electricity are at hand, the overhead equipment is already installed, and the available staff is accustomed to maintain electrical equipments.

TABLE IV.—*Comparative Cost of Petrol and Battery Vehicles.*

Size of lorry, 2½ tons.
Service, delivery, town and suburban, 10–15 miles radius.
Miles, per day, 35.
Working days per annum, 300.
Miles per annum, 35 × 300 = 10,500.

Capital Cost.

	Petrol.	Electric. Iron Battery.	Electric. Lead Battery.
	£	£	£
Chassis	550	525	525
Body	100	100	100
Battery	—	683	202
	£650	£1,308	£827

Standing Charges.

	£ s. d.	£ s. d.	£ s. d.
Interest on capital, 5 per cent.	32 10 0	65 8 0	41 8 0
Depreciation on body and chassis, 15 per cent. on petrol ..	97 10 0	—	—
Ditto, 10 per cent. on electric	—	62 10 0	62 10 0
Insurance, 3½ per cent.	22 15 0	—	—
,, 2½ per cent.	—	32 14 0	20 13 0
Rent and taxes	50 0 0	50 0 0	50 0 0
Driver's wages	150 0 0	150 0 0	150 0 0
	352 15 0	360 12 0	324 11 0
Standing charges, pence per mile	8·05	8·24	7·41
Tyres per mile	1·0	0·75	0·75
Petrol, 7 miles per gallon at 1*s.* 6*d.* ..	2·57	—	—
Oil, grease, repairs ..	2·2	1·00	1·00
Battery maintenance ..	—	2·73	2·30
Electricity at 1½*d.* ..	—	1·8	1·8
	5·77	6·28	5·85
Standing charges ..	8·05	8·24	7·41
	13·82	14·52	13·26
Total cost per annum ..	£605	£636	£580

TABLE V.

	Horse Wagon.	Electric.
No. of vehicles in service ..	107	47
Total cost per month per vehicle	£24 11 0	£38 13 7
Average ton-miles per vehicle per month	—	749
Average ½-ton miles per vehicle per month	383	—
Cost per ton-mile	30·6*d.*	12·37*d.*
Cost per mile	15·3*d.*	12·37*d.*

PETTER TWO-STROKE OIL ENGINES.

THE respective merits of the two-stroke and four-stroke cycles for internal-combustion engines have been under discussion for so many years that it must now be assumed that engineers are generally familiar with them. Powerful advocates can be found for both types, and there are, of course, particular applications in which one or the other is best suited, but where low first cost and simplicity of operation are important considerations a particularly strong

* Proc. I.A.E., vol. xvii, Part I, page 215.

36-42-B.H.-P. TWO-STROKE CRUDE-OIL ENGINE.

CONSTRUCTED BY MESSRS. PETTERS LIMITED, ENGINEERS, YEOVIL.

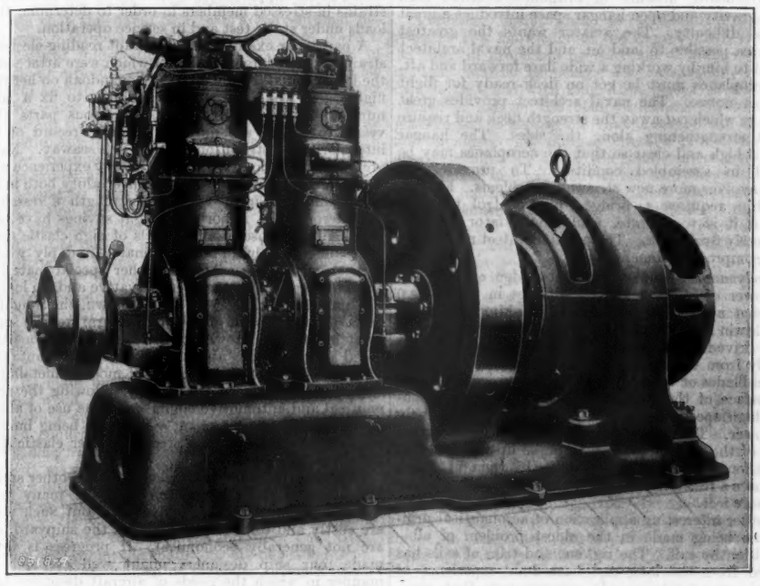
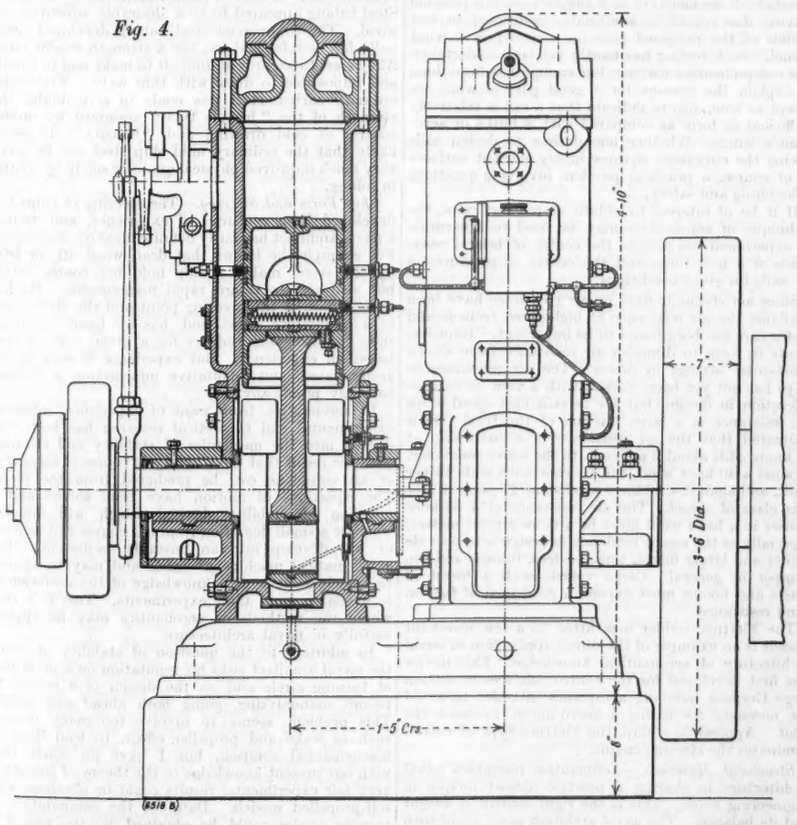


FIG. 3. 36-42-B.H.P. CRUDE-OIL ENGINE AND 24-KW. ELECTRIC GENERATOR.

Fig. 4.



case can be made out for the two-stroke cycle type. As far back as 1915, Messrs. Petters Limited, of Yeovil, decided to abandon the manufacture of four-stroke cycle engines, which they had previously made, and to concentrate on the production of the two-stroke cycle type, first made by them in 1911. This decision, which the firm state they have no reason to regret, has apparently done much to increase the popularity of the type, as many thousands of Petter oil engines are now in use in all parts of the world.

Two examples of the firm's latest models are illustrated on this and on the opposite pages. Figs. 1 and 2 are, respectively, a longitudinal and transverse section through a type "M" engine, which is designed to run on kerosene, or paraffin oil as it is often called, after using a small quantity of petrol for starting up, the change from one fuel to the other being effected automatically. As will be seen, the engine functions on the two-stroke cycle and is provided with high-tension magneto ignition. It is also fitted with a centrifugal governor on the crankshaft, operating on a baffle disc located between the crankcase and the inlet ports, and so regulating the admission of the charge in accordance with the load. The most important feature of the engine, however, is the fuel-injection system.

The fuel, as indicated in Fig. 2, is stored in the bed plate of the engine, from which it is drawn by a pump mounted on a cover of the crankcase, the pump being operated by the pressure variations of the air in the crankcase acting on a diaphragm. The oil is delivered to a chamber fitted with a needle valve and communicating with a spraying nozzle located in the inlet port, so that when the latter is uncovered by the piston, the fuel is delivered into the cylinder in a finely atomized form. The whole arrangement of the fuel-injection system can be followed by examining Fig. 2, from which it will be noticed that the fuel-suction pipe is fitted with a ball-foot valve, and that an overflow pipe is provided for the return to the reservoir in the bed-plate of any surplus fuel from the nozzle chamber. It is into the latter that the small quantity of petrol required for starting is filled, a screwed cap being provided for the purpose as shown in Fig. 2.

The two main crankshaft bearings are ring-oiled, and oil is supplied from the left-hand bearing in Fig. 1, through a spiral groove and hole to the crankpin, as indicated by dotted lines in the figure. The supply of oil to the well of the left-hand bearing is maintained from a sight-feed lubricator mounted on the cylinder water jacket, as shown in Fig. 1. The cylinder walls and gudgeon pin are lubricated by splashing. The other main features of the design can be followed from the illustrations without explanation, although attention may be directed to the large-capacity exhaust silencer which is bolted directly on to the flange of the cylinder as shown in Fig. 2. Engines of the type above referred to are made in three sizes, developing 1½, 3 and 5 brake horse-power, respectively, the illustrations given in Figs. 1 and 2, being reproduced from drawings of the 5 h.p. size of which the cylinder is 4¾ in. in diameter, and the piston stroke 4½ in.; the normal speed of the 5 h.p. engine is 600 r.p.m. These engines are supplied with tanks or hopper-type water coolers, and in the semi-portable and portable forms, as well as coupled to electric generators, pumps, compressors, and other machinery. The 1½ brake horse-power engine can also be supplied with an air-cooled cylinder if that type is preferred.

For higher powers and when greater fuel economy is necessary, the type of engine illustrated in Figs. 3 and 4, which Messrs. Petter designate as their type "S" engine, is more suitable than are the magneto-ignition engines described above. These engines are of the hot-bulb or so-called semi-Diesel type, in which ignition is effected by injecting the fuel on to the inner surface of the vaporiser, which is in direct communication with the cylinder and is maintained at the requisite temperature by the heat of the explosions. In starting up this type of engine it has generally been necessary to heat the vaporiser at first by means of a paraffin blow lamp, but the trouble and delay involved in this operation are avoided in the Petter engines by employing the firm's patent cold starter. This has already been illustrated and described in ENGINEERING, on page 55 of our issue of July 13, 1923, but we may remind our readers that it consists of a cartridge of combustible material mounted in a steel tubular holder, and inserted in a tapped hole in the vaporiser after having been previously ignited by an ordinary match. The combustion of the material of the cartridge supplies the heat necessary for starting and running the engine until the tubular holder has become hot enough to continue the ignition. After the engine has been running for some minutes, the vaporiser, of course, becomes sufficiently hot to function normally. These engines will run satisfactorily on crude or residual oils, as well as on refined petroleum, the consumption averaging about half a pint per brake horse-power per hour in the case of a fuel oil having a specific gravity of 0·9 and a calorific value of 19,000 B.Th.U. per pound.

Engines of the type illustrated are made with single cylinders in four sizes developing 5, 8, 12 to 14, and 18 to 21 brake horse-power respectively. Twin-cylinder engines are made in two sizes, of which the smaller develops 24 to 28 brake horse-power, and the larger 36 to 42 brake horse-power. The last-mentioned engine, which runs at 450 r.p.m. is shown direct coupled to a 24-kw. continuous-current generator in the half-tone engraving, Fig. 3, while a drawing of the same engine is reproduced in Fig. 4. Engines of the hot-bulb type are made with horizontal cylinders and also for marine work.

We propose to refer now to a few points in connection with the design of the twin-cylinder vertical engine, the main features of which can be followed from Figs. 3 and 4 without detailed description. First, it may be mentioned that the sprayer nozzle, when in position in the cylinder head, is completely surrounded by the

water-jacket which prevents the possibility of the fuel carbonising in the sprayer, due to overheating. The fuel pumps are driven by an eccentric from the crankshaft, the stroke being varied in accordance with the load by means of a centrifugal governor. The pump bodies are of bronze and are fitted with case-hardened steel plungers. A safety disc is provided on the delivery side of the pump to relieve the pressure in the event of an obstruction occurring in the fuel system.

As will be seen from Fig. 4, the main crankshaft bearings are lubricated by oiling rings, oil throwers being fitted at the outer ends to prevent the escape of oil. The crankpin, gudgeon-pin and cylinder walls are supplied with oil from a mechanical lubricator operated by the variations in air pressure in the crankcase; the internal and external connections for the purpose are clearly shown in Fig. 4. It will be noticed that oil for the cylinder walls is brought through connections passing through the water-jacket on opposite sides, a separate connection being provided to lead oil into the end of the gudgeon pin, which is hollow, as shown; holes drilled in the pin allow the oil to pass through for the lubrication of the small end bearing. For lubricating the crankpin, oil is delivered from the mechanical lubricator into an annular trough mounted on the web of the crankshaft, and flows to the crankpin, by centrifugal action, through a hole indicated by dotted lines in Fig. 4.

As previously mentioned, the firm's cartridge self starter is used when starting up, and the single-cylinder engines, being fitted with a compression relief valve, can all be turned by hand for the purpose. With the twin-cylinder engines, compressed air is used for starting, and an automatic valve driven from the crankshaft is provided to distribute the air correctly between the two cylinders. The arrangement obviates the possibility of the whole supply of compressed air being lost without effecting a start. In conclusion, we may mention that the makers claim that, if required, the engines will run light for any length of time without special adjustment, this feature having been rendered possible by special attention to the design of the combustion chamber. With most engines of the type referred to, it is necessary to employ a blow lamp to maintain the temperature of the vaporiser when running light for long periods.

AERONAUTICS IN NAVAL ARCHITECTURE.*

By Commander J. C. Hunsaker, C.C., U.S.N.

As aeronautics passed from the hand of inventors into the hands of engineers it borrowed heavily from naval architecture as well as from other branches of engineering. But both aeronautics and naval architecture have in common the fundamental laws of fluid motion, balance and stability, and moreover have in common the practice of basing a design upon tests with reduced scale models. Consequently, as aeronautics acknowledges its largest debt for naval architectural knowledge and practices, it seems reasonable to inquire whether the time has not now come for some portion of this debt to be repaid to naval architecture in the form of aeronautical knowledge and practices which may usefully be applied in ship design.

Warship Design.—It is beyond the scope of this paper to discuss the possible effects of aeronautics on warship design, and it is still too soon to speak with any confidence. However, the question is constantly being raised in Congress and in the press. The bombing tests on ex-German warships conducted by the Army and the Navy clearly show that the warship has a new enemy and must take account of his weapons. The great weapon of the aeroplane is the heavy bomb which explodes under water. To meet this, the warship requires the same kind and degree of underwater protection that is needed against mines. To avoid mines, warships keep clear of coastal waters. In the present state of the art, no airplane can carry a heavy bomb beyond such waters and release it at a safe height.

The best antidote against hostile aircraft is, as mentioned above, to keep out of coastal waters. Mines and submarines already have made coastal waters an unsafe region for a fleet. At sea, the only offensive aircraft to be met are those launched by the enemy fleet. To meet them, aircraft superior in number and quality are needed. Therefore, an essential feature of a modern fleet must be ability to throw out an air force when required.

Aircraft may be carried either on special flush deck vessels called carriers, or on men-of-war. They can return to the carrier or "land" on the water to be picked up like a boat. Seagoing aircraft operating independently must base on shore in the present state of the art and may not figure in a fleet action on the high seas.

The carrier is a new type of vessel which the naval architect and aeronautical engineer have worked out together. Underwater there is nothing new, but the high freeboard, absence of ordnance weights, high centre-gravity and open hangar space introduce a great deal of difficulty. The aviator wants the greatest deck area possible to land on, and the naval architect gives it to him by working a wide flare forward and aft. The aeroplanes must be got on deck ready for flight on short notice. The naval architect provides great elevators which cut away the strength deck and require special strengthening along the sides. The hangar space is high and clear so that the aeroplanes may be stowed in assembled condition. To provide this space involves more new structural problems. Finally, the ship requires a bridge, fire control top and radio if it is to operate, while the aviator wants a completely flush deck. The naval architect must work out a compromise somehow.

Aerodynamics.—Our recent knowledge of the lifting power of inclined curved surfaces in air (wings) has been applied in the design of skimming boats by Baldwin and Graham-Bell and others. Such boats, when driven at high speed by air propellers, rise entirely from the water, and are sustained by the lift of steel blades or wings carried on legs projecting under the surface of the water. By such means, astonishingly high speeds have been obtained with relatively low power. There is a complete elimination of a great many of the factors that go to make up resistance to propulsion. Blades that will lift 15 tons in water may have a resistance of only 1 ton and an area of some 15 square feet.

Another interesting application of aeronautical principles is being made in the oldest problem of all—propulsion by sail. The rig, cut and trim of sails has evolved from the long and hazardous experience of our seagoing forebears. It appears now that aeronautical knowledge may have a bearing on the problem and several alterations in practice have been suggested. To establish the merits of such suggestions, it is possible (paying due regard to similitude conditions) to test models of the proposed sails on a model in a wind tunnel. Such testing has hardly yet been undertaken in a comprehensive manner, but enough has been done to explain the reasons for a good part of what we accept as true, also to indicate that a sail is relatively inefficient in form as compared with a bird's or aeroplane's wings. Whether one desires to design sails having the curvature of those highly efficient surfaces is, of course, a practical problem involving questions of handling and safety.

If it be of interest to obtain more exact rules, the technique of aeronautics may be used to determine by experiments on models the centre of lateral resistance of a hull form and the centre of pressure on the sails for given conditions.

Since aerodynamic data on air resistance have been available the air resistance of high-speed trolleys and motor-cars has been found to be important. Improvements in form to diminish air resistance have shown substantial savings in power. The air resistance to ships has not yet been studied with a view of its consideration in design, but for certain high-speed ships air resistance is a large fraction of the total. It is estimated that the air resistance of a battleship at 20 knots adds about 3 per cent. to the water resistance. Against a 40-knot wind, the air resistance adds 12 per cent., and against a 60-knot wind some 27 per cent. for this class of vessel. The air resistance of a 35-knot cruiser in a head wind must be a more serious matter, especially as the recent tendency in design is to provide higher and larger masts, tops, bridges, funnels and top hamper in general. Cargo vessels with a forest of masts and booms must expend a good deal of fuel on wind resistance.

The Flettner rudder now fitted to a few merchant vessels is an example of the direct application in naval architecture of aeronautical knowledge. This device was first developed for the control surfaces of certain large German bombing aeroplanes in order to avoid the necessity for fitting a servo-motor to assist the pilot. Applied to a ship, the Flettner type of rudder eliminates the steering engine.

Structural Materials.—Aeronautics resembles naval architecture in sharing a practice almost unique in engineering work. This is the rigid control of weight and its balance. The naval architect saves a ton with satisfaction, but the aeronautical engineer normally tries to save pounds. A few tons overweight on a ship is not noticed, but 50 lb. overweight on an aeroplane may mean the sacrifice of a vital piece of military apparatus and make the machine a relative failure. In aeronautics, weight saving is all important and is often carried to such lengths that cost is completely ignored. The design of structural members is carried out with every refinement indicated by theoretical structural analysis, and then checked by static tests on a full-sized aircraft. In order to save weight, indeterminate structural arrangements are employed whose analysis by theory is often uncertain. It is not satisfactory in aeronautical design to use a liberal factor of safety to cover uncertainties. Consequently methods and apparatus have been devised to measure strains in stressed members in order to determine then loads under static test and in service operation.

A particular example is the distant reading electrical strain gauge, a large number of which were attached to the longitudinals of the airship Shenandoah on her trial flights. It would be a simple matter to fix a large number of these instruments to various parts of a vessel to obtain a "moving picture" record of the intensity and distribution of stress in a seaway. Naval architecture is frankly going entirely by experience with liberal factors of safety to cover uncertainty both in the longitudinal and in the transverse strength of vessels.

In aeronautics, important weight savings have been realised by the use of alloy steels of high elastic limit, light alloys of aluminium, laminated and ply woods, high strength wire cable and other special materials. Shipbuilding is necessarily conservative and, so long as the hull stresses in service are unknown, the weight to be saved by adoption of better structural steels is somewhat indefinite. However, there are indications that naval architecture is about ready to take advantage in a practical way of the products of modern metallurgy. The marine engineers are already following the aeronautical and automotive engineers in the use of alloys. In England a few merchant vessels are being built to reduced scantlings with a steel of higher elastic limit than is usually employed.

Of course, for warships, nickel steel and other special high-strength steels have been used for many years where high stresses were expected. But such steels are costly and difficult to handle in the shipyard, and are not generally economical. If progress is to be made, our ship designers might well consider the manner in which the needs of aircraft designers have been met by intensive research to develop materials having the properties especially desired for aircraft construction. A case in point illustrates my meaning. Steel tubing appeared to be a desirable substitute for wood. The commercial steel tubing developed originally for bicycles had too low a strength-weight ratio. Alloy steel tubes proved difficult to make and to handle and impossible to draw with thin walls. Eventually ordinary carbon steel was made to give double the strength of the "bicycle tube" standard by careful control of cold drawing and "blueing." It seems likely that the ordinary mild ship steel can be given very much improved physical qualities solely by control in rolling.

Ship Form and Steering.—The steering of ships has developed from centuries of experience, and to-day a naval architect has fairly definite ideas on the subject. For example, he knows that dead wood aft, or trim by the stern, makes a ship hold her course better but also acts to retard rapid manœuvring. He has some notion of the pivoting point and the drift angle in a qualitative sense, and has at hand empirical rules for designing rudders for a given type of ship based on experience. But experience is very slowly accumulated, and qualitative information is difficult to apply practically.

In aeronautics, from want of experience, intensive experimental and theoretical research has been conducted into the mechanics of stability and steering, with the result that the stability of course of an airship or an aeroplane can be predicted from the plans. The equations of motion have been solved and a criterion of stability devised which will indicate whether a small deviation from the course will increase or will develop into an unstable oscillation. The mathematical machinery* exists and may be applied to vessels as soon as a knowledge of the coefficients† is available from tank experiments. This is a case where the methods of aeronautics may be applied usefully in naval architecture.

In addition to the question of stability of route, the naval architect risks his reputation on a prediction of turning circle and on the design of a rudder to permit manœuvring, going both ahead and astern. This problem seems to involve too many factors, such as wake and propeller effect, to lend itself to mathematical solution, but I have no doubt that with our present knowledge of the theory of similitude very fair experimental results could be obtained from self-propelled models. Data for the computation of turning circles could be obtained by the use of a circular tank, with the model towed by a whirling arm. The whirling arm is an aeronautical device, having been introduced by Langley in his pioneer work in air resistance.

As to the design of rudders themselves, the aeronautical literature already contains a great deal of

* Abstract of paper read at the meeting of the Society of Naval Architects and Marine Engineers, in New York, November 13 and 14, 1924.

* G. H. Bryan: "Stability in Aviation."

† L. Bairstow, Advisory Committee for Aeronautics, London, 1912–13.

information of immediate use to the naval architect. The centre of pressure on flat and cambered surfaces, balanced or unbalanced, has been found for a great variety of shapes from tests made in air. There is ample evidence that the centre of pressure is the same for air and for water. The aeronautical experiments indicate that the naval architects's conventional use of Joessel's formula for rudders is far from correct. Aeronautical information as to the distribution of pressure on a rudder and on the dead wood is applicable in naval architecture. For a separate rudder working in clear water the total normal force on the rudder is made up to a large degree by suction on the rear side. Also the unit pressures are relatively very high over the leading quarter of the rudder length.

For a rudder hinged to a flat dead wood, the principal force acting to turn the ship when the helm is put over is not on the rudder at all but on the dead wood. This is the reason that rudders of aircraft are usually hinged to the trailing edge of a fin. It is found that a small rudder acting with a good-sized fin produces ample turning moment on the aircraft with little stress on the steering cables. A further advantage of the rudder-fin combination is that the normal force produced on the fin (or dead wood) is transverse and does not hinder speed. Johns has pointed out that on the old sailing frigates the rudder area was relatively small, its main purpose being to bring a pressure on the dead wood. The ship thus retained steerage way when coming about on the other tack. Aeronautical research confirms the judgment of the designers of those sailing frigates, but gives us data in quantitative form. It may be noted here that aerodynamic forces may be multiplied by 823 (ratio of densities) to obtain the corresponding forces in sea water.

Propeller Design.—Marine propeller design is based on data obtained from models and from trial trips. In either case similitude conditions are depended upon, and the detail mechanism of propeller action is apparently considered too hopelessly complicated for successful analysis. The Wright brothers, knowing nothing of marine propeller theory and unaware of the hopelessness of detailed analysis, attacked the design of propellers for the first aeroplane with characteristic thoroughness. They had already successfully analysed the action of their glider wings, and had discovered the experimental facts of lift and resistance.

As a result they applied this knowledge to the blades of a propeller and produced a remarkably efficient design. Other experimenters, notably Drzwiecki and Lanchester, had in the meantime developed a "blade element" theory, which proposed essentially to determine experimentally the forces on an element of a propeller blade from tests on an aeroplane wing moving through the air. The thrust and torque per blade could then be computed by integrating graphically. The development of aeronautical propellers has in the main followed the blade element theory, and, although this theory is far from satisfactory, practical aeronautical propellers are designed which exceed 80 per cent. in efficiency and which meet torque and thrust conditions with reasonable precision.

One advantage of the detailed analysis comes from the light thrown upon the effect of the curvature of the back of the blade. It is now clear that the curvature of the back of the blade is most important. A high camber gives a high thrust per unit area and somewhat reduced efficiency, other conditions being equal. Also, it is learned that for a cambered blade the angle of incidence may be from 2 deg. to 8 deg. negative before the lift or thrust component of force on the blade element vanishes. This "angle of no lift" is a characteristic of the blade section. Consequently, the marine propeller designer's preoccupation with "pitch," variously defined, appears to be unnecessary, as pitch is not a true propeller characteristic. Likewise, "slip," whose definition involves pitch, becomes wholly deceptive. The abnormality of "negative apparent slip" is familiar to us, but we now know the words mean very little.

What has happened in a case of negative slip is that the angle of incidence of the blades (measured from the face) is negative although the angle of incidence measured from the "angle of no lift" is still positive. Consequently the effective pitch is larger than the geometrical face pitch, and real and apparent slip are different.

Aeronautical propellers never had to discard the pitch and slip notation, because it was never adopted generally in reporting results of propeller experiments. Instead, the ratio $\frac{V}{N D}$ was used as a prime variable. The diameter for any one of a family of similar propellers includes all we mean by pitch, however defined, and the ratio of speed of advance to N D includes all we mean by slip. In fact, for a given propeller, $\frac{V}{N D}$ is characteristic of its operation and may with reason be called a slip coefficient. The thrust, torque and efficiency are each functions of $\frac{V}{N D}$. The advantages in clearness and convenience in presenting propeller test data on a basis of $\frac{V}{N D}$ are beginning to be appreciated by marine propeller workers.

A further useful result of aeronautical propeller research is a knowledge of the improvement that can be made in propellers by selection of a correct blade section. Marine propellers, for reasons of strength, cannot be made with long, thin blades of maximum efficiency, but for the blade thickness required it is possible to choose a profile that is rather bad, and still not obviously very different from a profile that will give best efficiency under the conditions of working.

The blade element analysis has also shown that the angle of incidence largely determines the effectiveness of each element. This angle of incidence is the angle made between the direction of motion relative to the air or water and a reference line on the blade element. As a ship's propeller is working in the wake, the motion of the water is so disturbed that the estimate of angle of incidence is often little better than a guess.

Kempf has shown how to map experimentally the "effective" wake behind a ship's model, and, with this knowledge, the blade elements of the propeller may be set so that each is working to best advantage.* Conversely, wake conditions which are undesirable for propeller efficiency may be discovered and corrected. This virtually amounts to fitting the propeller design to the hull design. The opportunity of make what Kempf calls the "second approximation" in propeller design comes from adopting the aeronautical propeller designer's analytical point of view.

At the present time the hydrodynamical circulation theory which has proved so useful in calculating the forces on wings and the distribution of pressure is being applied to propeller blades. The work is hardly complete, but it already appears probable that it will soon lead to a simpler and more precise procedure for the design of air propellers.

Marine propellers are unique in having ever present the possibility of cavitation. I venture to suggest that an explanation of cavitation will be found in the distribution of pressure over the blade profile. This could be investigated theoretically by the circulation theory and experimentally with models using the methods of aeronautics.

* G. Kempf: "Praktische Propellerkonstruktion in Zweiter Näherung." Hamburgische Schiffbauversuchsanstalt, December, 1923.

SELF-UNLOADING BULK CARGO VESSELS OF THE GREAT LAKES.†

By Henry Penton, and Professor Herbert C. Sadler, D.Sc.

† Paper, abridged, read before the Society of Naval Architects and Marine Engineers, at New York, on November 13, 1924.

The present-day bulk freighters of the Great Lakes represent one of the most interesting developments of ship design. They typify the extreme case where the equipment for handling cargo is entirely absent so far as the ship is concerned, the appliances for both loading and unloading being situated ashore. Of recent years, however, another type has been developed, also for handling bulk cargoes, and which may be considered as at the other extreme, namely, a vessel which carries on board a complete mechanical equipment for unloading entirely independent of any and all shore plant. These vessels have come to be known as "self-unloaders," and as the authors were responsible for the original designs of the different types it was thought that an outline of the method of solving the problems involved and some description of the leading features of the vessels would be of interest. In general the bulk cargoes handled by these vessels consist of stone, coal and cement.

In 1907, to meet the requirements of a concern on the Great Lakes using annually some hundreds of thousands of tons of limestone in chemical processes, one of the authors developed a design employing a conventional single-deck, bulk-freight type of hull and installing therein a self-unloading, continuous conveyor system which delivered the cargo overside without the assistance or intervention of any form of auxiliary or shore equipment. The ship was designed for handling what is known to the trade as 4-in. stone, but the adaptability of the system to handling coal also became almost immediately apparent, and it has since been steadily employed in both trades. The first ship was placed in commission in the early summer of 1908. Up to that time the water-borne movement of stone reached comparatively small figures and was handled almost entirely in small open barges and unloaded by shore equipment. The advent of the self-unloader gave this movement great impetus and, combined with the development of certain favourably located formations of stone of a character highly desirable for flux as well as for chemical properties, has developed a movement which by the close of 1923 had reached a volume of 10,000,000 short tons in the navigation season. Not all of this was moved by the self-loaders however, a considerable part being handled by ships of the ordinary type and unloaded by shore equipment, but figures for the relative proportions are not available. Similarly the figures for the self-unloaded coal are buried in the total water movement for the season of over 33,000,000 short tons. There are now eleven ships of the continuous conveyor type in commission.

In general, the self-unloader in the stone and coal trades (see Figs. 1 and 2) employs two horizontal conveyors, symmetrically arranged each side of the centre line, delivering at the forward end, through a combining hopper, to the heel of an inclined conveyor or elevator which in turn delivers to the heel of a boom conveyor which can be swung over either side through a total arc of approximately 200 deg. The hold conveyors are placed immediately upon and parallel to the tank top, the forward end being carried upward to a sufficient elevation to get a proper run through the combining hopper to the centre-line elevator. The heel of the latter is placed as close as possible to the peak bulkhead and it has sufficient rake to insure proper feeding and discharging. The boom is pivoted on deck directly below the head of the elevator and, when not in use, is stowed and secured in chairs on the centre line. It may be topped up to any desired angle within the working limits, which approximate 20 deg. from the horizontal. It may be of almost any desired length, but up to the present 150 ft. has been found to be as long as is necessary with a minimum of about 85 ft. The effective delivery radius is sometimes materially increased by the addition of an apron under the outboard end. The elevator is of the chain-belt bucket type and the boom conveyor of the troughed rubber-belt type.

To obtain a flow of material to the conveyors the cargo hold is built with a bottom approximating, in cross section, the shape of a flattened W (see Fig. 3). The flattest slopes at which stone would flow without some kind of agitation or disturbance was found experimentally to be 35 deg. from the horizontal. The loss of capacity due to this construction is not important with stone, which, in the sizes commonly handled, averages about 23 cub. ft. per short ton, but with coal, at about 38 cub. ft. per short ton, the loss is substantial. To minimise this loss it would be desirable that each of the legs of the W should be of the same length, but this is impractical because of interferences forward where the hold conveyors would foul the shell, and because of the greater height to which the heads of these conveyors would need to be carried to obtain a proper flow through the combining hopper to the elevator. In effect, therefore, there exists a tunnel between the conveyors under the cargo hold proper. In the bottom of the hoppers, over the conveyors, there is formed a series of hinged gates which are controlled from this tunnel. Some of the larger and more recent ships have a mechanically-operated feeding mechanism added to these gates to control the flow of material. With the larger sizes of stone particularly this is sometimes an advantage, because of the tendency of the stone to bridge and the subsequent flooding of the conveyor when dislodged.

The hold conveyors are in general of two types—the pan or bucket type and the belt. Both have proven very satisfactory, and the choice is largely one of preference. The former, because of its link or chain-belt construction, can be guided in straight lines fairly close up to the delivery end and the length of slope restricted, while the latter necessarily assumes a catenary with a much longer slope. For stone cargoes only this is unimportant, but it aggravates somewhat the loss of capacity for coal.

The first ship employed electric drive for the conveying machinery. Some of the succeeding ships employed steam drive, but all of the later vessels have used the electric drive. Where steam is employed the prime mover is located forward, and heat losses, independent of those due to the comparatively uneconomical type of engine employed in most cases, are naturally very high and the drives very indirect. On the other hand, a strong argument in its favour has been found in its comparative simplicity and reliability, and the actual hours of running are not great. The electric drive, however, in the latest as well as the largest installations has proven reliable and free from trouble, and, in spite of electrical losses, much the more economical. There is also a substantial saving in weight and, further, the feature of permissible remote control of all motors, and consequently of each unit of the system, is easily arranged for, so that the entire system can be controlled from the deck if desired, as well as from the different stations.

Figs. 1 and 2 show the arrangement of a ship of about 8,000 tons capacity in stone, and illustrate the general arrangement of all chain-belt conveyor ships.

With respect to unloading rates, these vary from

about 800 tons per hour in the earlier examples up to 1,800 tons to 2,000 tons per hour in the later and larger ships. It thus comes about that the port unloading time works out about the same for all. The unloading rate depends not only on conveyor widths and speeds, which have been gradually increased since the first installations, but also to a considerable extent upon the freedom of flow of the material. When we first approached the problem the size of stone to be handled was what is known nominally as 4-in., but the sizes now handled, particularly in flux stone, are much larger, and pieces are frequently met with which may reach 18 in. to 24 in. in one dimension. In coal also large lumps frequently occur, and these not only lead to bridging but may have to be broken up *in situ* in order to restore flow. Provision for this is made by means of openings in the hopper sides above the gates and through which bars can be manipulated. Coal is easily disposed of, but occasionally large lumps of stone cause considerable trouble. This lack of uniformity and consequent irregularity in feeding has led to the fitting of the mechanical feeding devices before referred to.

worked out the arrangement shown in Fig. 4, which gives an outline of the section of a 12,000-ton ship, of which the usual arrangement is shown in Fig. 3. The modified arrangement produces an increase in area of section of about 225 sq. ft., and, since the length of hold affected is about 380 ft. and of nearly uniform section, the gain in coal capacity is about 2,000 short tons, or about 28 per cent. Since the increase is added entirely to the lower side of the cargo it is not affected by trimming. Untrimmed cargoes are the rule, and figures quoted throughout are on that basis. It will be observed that this plan produces a practically rectangular cargo hold, and offers either increased capacity for certain cargoes on the one hand or reduced costs for a ship of a certain capacity on the other. Improved stability follows as a matter of course, and that a stable ship of hitherto impractical dimensions is now feasible has already been demonstrated. It may be added here that, theoretically, a self-unloading ship of Welland canal dimensions should be able to carry, on normal canal draught, 14 ft., about 2,250 short tons deadweight; the actual vessel is

in the tunnel, but the relative areas are indicated by the triangle above the head-room limit line. For convenience, a scale has been added whereby comparisons may be made directly.

Increase in beam or depth now produces an increase in capacity in exactly the same proportion as in any other ship. The comparative weights of the ordinary and modified types are about alike, if anything a little in favour of the latter, because the articulated leaves are not subject to any great weights or stresses and may be light. The only stresses imposed are at the beginning of movement under the weight of cargo contained in the triangle of which the hypotenuse lies at the angle of repose of the cargo. The instant this repose is disturbed ever so slightly the weight falls off rapidly. The stiffening required under the long fixed slopes is materially reduced, and the entire suppression of the transverse hoppers does away with a lot of material and fitting and riveting, of which one-half is treble-riveted watertight work. On the other hand, the number of gates is somewhat increased. So far as our present information goes, the costs are at least

Fig. 1.

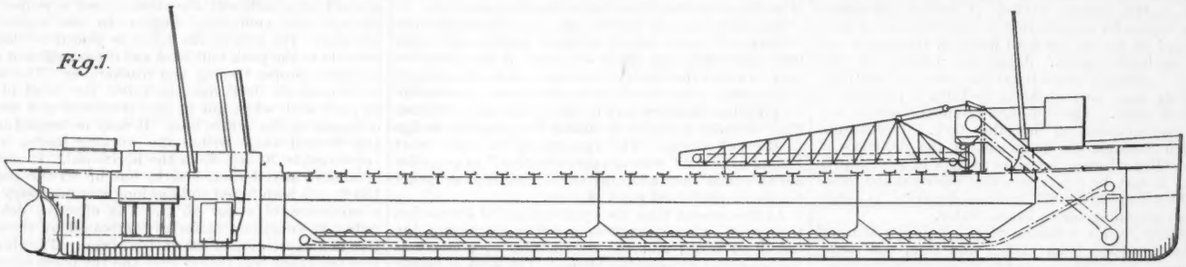
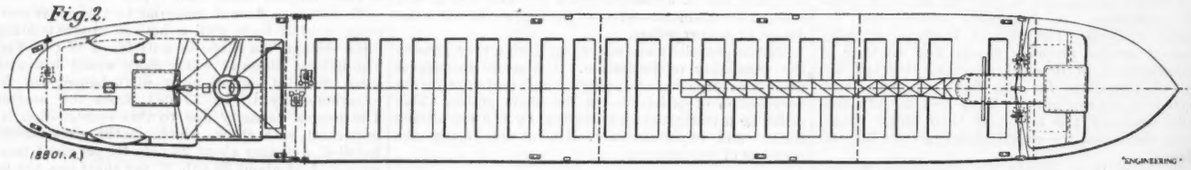


Fig. 2.



In general, the self-unloader is adaptable to any cargo which will flow by gravity, and is of sufficiently hard and irregular a nature to avoid interlocking and bridging; for example, bricks could not be handled at all. It cannot be used for the ores of the Great Lakes because of the fines and moisture, but for nodulised or sintered ores it is perfectly adaptable.

It will be apparent, of course, that the self-unloader suffers loss in both capacity and deadweight, and the offsets are to be found in saving in port time, total independence of any and all forms of shore unloading plant, independence of shore labour and working conditions or fixed hours, ability to demand and collect an unloading rate in addition to her freight, ability to make delivery at any point where she can make fast, and which naturally produces much business which is not only not available to any other type, but which would not otherwise exist and which carries with it non-competitive freights. Further, it is best on the shorter trade routes because of the quick turn-rounds. One of these ships has handled 110 cargoes in a season of about 240 days, taking stone in one direction and coal in another, and frequently taking three cargoes in a round voyage.

It will be readily apparent that the hoppered design is restricted in two directions. The high centre of gravity leads to instability in ships of certain dimensions, as, for example, in a ship for the Welland and St. Lawrence canal trade. Further, beyond a certain point, increase in beam and depth does not produce proportionate increases in capacity because of the area of cross-section cut off by the rise of hopper, and since increasing depths involve other objections, the economically largest ship of this design is probably of about 12,000 short tons deadweight capacity. Probably few trades could employ a ship of greater capacity. It follows that if some way were found to eliminate the hopper construction with fixed slopes and still retain gravity flow to the conveyors, two major advantages would accrue—improved stability in vessels of restricted dimensions in trades from which the self-unloader has been barred, and reduced dimensions and weights and costs for a given capacity. Or, from another angle, since a ship of the ordinary type, if designed for full stowage with stone, will have a coal capacity of only about 60 per cent. of her deadweight ability, the same ship would be able, if the hoppering could be suppressed, to carry considerably greater cargoes of coal while her entire cargo deadweight ability would be absorbed in stone with considerable capacity to spare.

With these ends in view one of the authors has

Fig. 3.

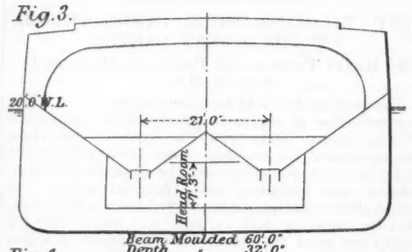
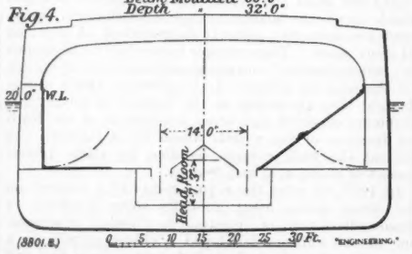


Fig. 4.



reported to have loaded about 2,200 tons. Briefly, the modification consists in articulating the hopper bottom so that normally the leaves are retracted, and in this position the lower leaf lies upon the flat of the side tank while the upper leaf hangs against the face of the webs, as shown at the left of Fig. 4. The cargo flows to the conveyors until flow ceases or is about to cease; the leaves are then moved inward as shown at the right of Fig. 4, dumping the remainder of the cargo into the conveyors. Any convenient method of operating the leaves may be employed; in one ship they were arranged for operation by wire-rope pennants shackled at the lower hinge joint and led to line-shaft drums under the deck. This is not ideal for the reason that conditions require at first maximum power with minimum motion and are best satisfied by hydraulic control or a toggle movement.

This plan allows us to go back to the desirable close spacing of conveyors; in fact, that arrangement becomes more than ever desirable because it lowers the apex along the centre line. Some slight hoppering here is unavoidable because of the head-room necessary

no greater, and there is reason to believe that under parallel conditions of construction they will be less than for a ship of equal capacity of the ordinary type.

Another type, which presents certain problems of a character somewhat different from the preceding, is a vessel arranged for carrying cement in bulk. What might be called the fundamental features are approximately the same, namely, a hopper construction with conveyors under, which feed to elevators at the forward end and from thence discharge overside through similar conveyors. Owing to the nature of the cargo, the screw type of conveyor is used, and while arranged primarily for the handling of cement, it may be remarked that these vessels could also handle such cargoes as grain, flax and other substances in which the individual particles are relatively small. It is, of course, well known that these last mentioned cargoes are very mobile, but it may not be realised that cement, especially when first loaded and therefore in a somewhat aerated state, will flow almost as a liquid. In designing, therefore, it is advisable to treat it as practically a liquid cargo so far as stability is concerned.

It may be remarked here that in respect of propelling machinery all the self-unloaders follow what may be called the standard lake practice. With a few exceptions, where quadruple engines have been fitted, all have triple engines and cylindrical boilers, and all work with either positive or induced mechanical draught.

A number of other plans have been put forward having in mind more particularly conversion of old bulk-freight ships to self-unloaders. One of these at least has been put into service, and consists in general of two tunnels under the cargo hold with a drag-line scraper in each and delivering to a centre-line elevator and boom similar to the continuous system. Of course, this system is intermittent and its hourly capacity relatively low, but its cost is said to be also low, and it affords an outlet for some tonnage no longer suitable for use in general trade.

The Royal Institution.—"Concerning the Habits of Insects" is the subject of the ninety-ninth course of Christmas lectures to be delivered at the Royal Institution this year by Mr. F. Balfour Browne, lecturer in entomology at Cambridge. The first lecture is on December 27, on "Insect Collecting and what it leads to," followed by the "Habits of Bees and Wasps" (December 30), "Habits of Caterpillars" (January 1), "Habits of the Dragonfly" (January 3), "Habits of the Water-Beetle" (January 6), and the "Habits of Insects and the Work of Man" (January 8).